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ABSTRACT

Based on the assumption that during the next quarter century the academic labor market will be chronically depressed, a project was undertaken to create models for projecting college faculty demographics. In this report the statistical models and the results of their application are explained in detail, including extensive statistical tables. Among the issues examined are: the effect of variation in enrollment growth; the results of allowing the rate of faculty promotion to fluctuate with excess demand (supply) of faculty; the results of increasing the level of outmigration of tenured and nontenured faculty from academia; the impact of the current elimination of mandatory retirement and the impact of programs that encourage faculty to retire early; and doctorate women and their future representation in academia. (MSE)

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U.S. Faculty After the Boom: Demographic Projections to 2000

A Report For The Carnegie Council on Policy Studies in Higher Education

Luis Fernandez

ED165618

Project on Quantitative Policy Analysis Models of Demand and Supply in Higher Education

Technical Report No. 4

April, 1978

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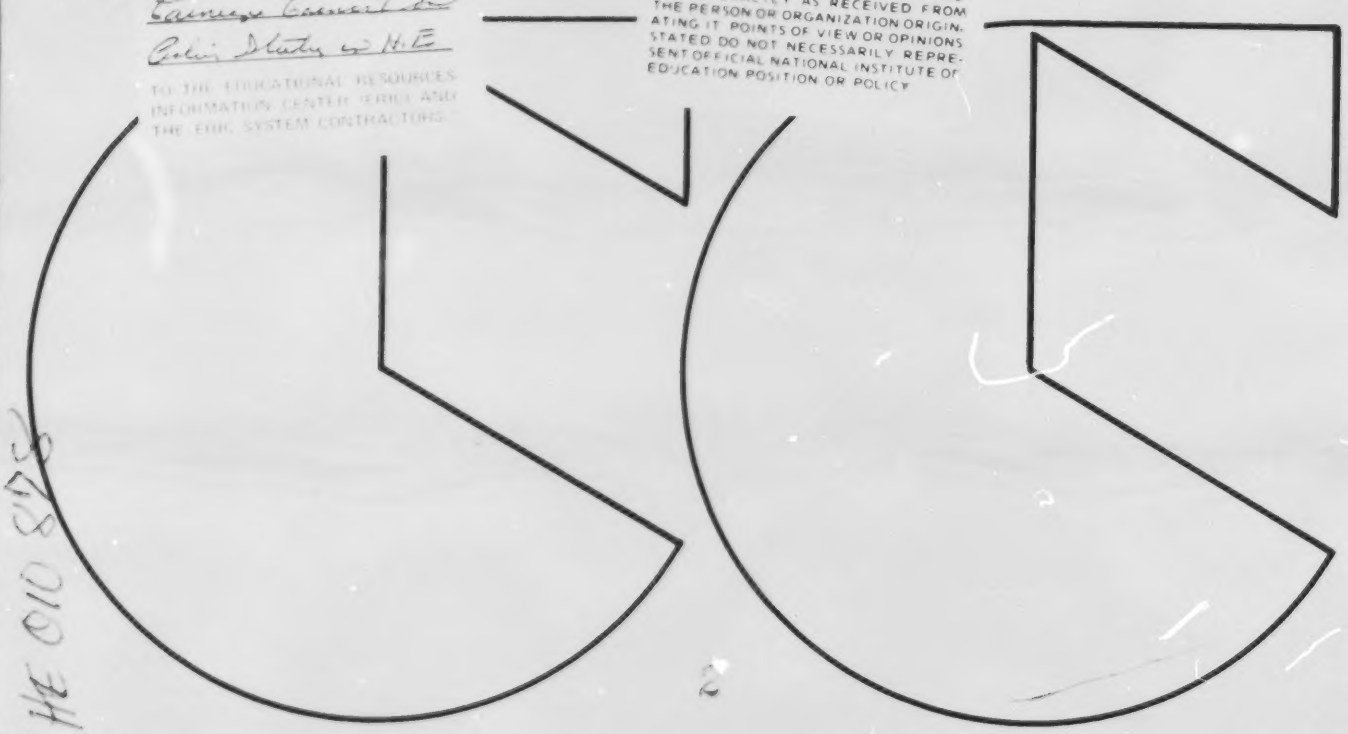

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U.S. DOCTORATE FACULTY AFTER THE BOOM: DEMOGRAPHIC PROJECTIONS TO 2000

Luis Fernandez

Technical Report No. 4

April 1978

Carnegie Council on Policy Studies

in Higher Education

Project on Quantitative Policy Analysis Models

of Demand and Supply in Higher Education

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Preface

The academic labor market during the next quarter-century promises to be very different from recent experience. The adjustments to the predicted contraction in demand for doctorate faculty are likely to be complex, requiring careful modeling in order to predict the impact of various policies for ameliorating the dislocations and preserving faculty vitality. We have constructed a model designed to elucidate the demographic development of U.S. faculty in the years ahead. Although we are making significant departures from his methods, our approach is based on the work of Allan Cartter [1976]. Like him, we view faculty as moving through different states, characterized by age and tenure status, and posit a Markovian model of transition between states.

The report is divided into two parts. The first is a presentation of the projections obtained from the model; the second explores the Markovian model used and the construction of our transition probabilities.

A number of people helped me to prepare this paper. Foremost were Roy Radner and Charlotte Kuh, who provided much of the guidance and support I needed to complete this report. I also learned much from conversations with Glenn Woroch, Gerry Duguay, Peggy Heim, Lew Solmon, and Tom Rothenberg. Lucas Arzadon, Janice Murray and Katie Triest helped type the manuscript. I also thank Barbara for putting up with my moods while I worked on this paper. This research was undertaken for the Carnegie Council for Policy Studies in Higher Education and was supported in part by the Ford Foundation and the National Science Foundation.

CONTENTS

1. Introduction and Summary 1

2. Projecting Faculty Demand 7

3. Promotion Rates 40

4. Quit Rates 61

5. Retirement Rates 86

6. Projections of Doctorate Women in Academia 104

7. Conclusion 118

Footnotes 122

References 125

Appendix:

1. The Mathematics of Our Projections 127

2. Variances of the Projected Population Means 136

3. Estimation of the Model's Parameters 145

I. Death and retirement rates 145

II. Promotion rates. 155

III. Quit rates 160

IV. Initial age distributions 163

V. Ages at entry 165

1. Introduction and Summary

The academic labor market during the next quarter-century promises to be chronically depressed. All indicators point to a slowing down and eventual contraction in total enrollments at four-year institutions, a reversal of the rapid growth in the 1960s that led to a 138% expansion in full-time faculty between 1960 and 1970 (N.C.E.S. [1973]). In 1973, 72% of undergraduate enrollments at four-year colleges and universities were 18 to 21 years old. Census projections show that by 1985, the number of people in this prime college-attending age bracket will have fallen back to the 1973 level. Although the percentage of this group attending college has been steadily increasing, projections by Cartter [1976] that assume a continuation of this trend show at most a 12% increase in enrollments between 1973 and 1985. Already, graduate enrollments are leveling off (N.R.C. [1975]) in the face of an estimated 33,000 Ph.D.'s competing for only 9,000 new junior faculty positions in 1975 (author's estimate).[1]

From the historical record of the academic labor market, the current disequilibrium can be expected to lead to an increased flow of experienced faculty to non-academic employment (Freeman [1971]) and to a fall in the rates of promotion to tenure (Radner and Kuh [1977]). Projections, then, obtained by simply extrapolating the current percentages of junior faculty receiving tenure or the fraction of faculty leaving university employment (which we will refer to as "academic quits") can be expected to show a more severe aging and "tenuring-in" of faculty (i.e., an increase in the fraction of faculty with tenure) and a more depressed level of hiring for new doctorates than will probably occur. In addition,

the age composition of the faculty can be expected to influence the rate of retirements and the level of inter-institutional movement, as older faculty tend to move less (Marshall [1964]) and certainly retire in larger numbers. Correcting for each of these effects in a piece-meal fashion is not a good way to provide accurate forecasts of labor market conditions or faculty characteristics (such as its age distribution). It is precisely accurate numbers that are needed to answer such questions as: When faculty-student ratios fall, what is the level of increase in quits by experienced faculty required to keep hiring unchanged? How many positions are "freed" if faculty begin to retire at earlier ages (voluntarily or not)? By how much, given the present pools of qualified women and minorities, will affirmative action programs in hiring and promotion change the sex and race composition of academia? Which is the best policy for slowing any increase in the tenure ratio: early retirement plans or tenure quotas (remembering that faculty denied tenure can always leave academia rather than look for another appointment)? How much of an error is likely to result from assuming that the proportion of the faculty promoted, retiring, etc., is independent of the age distribution? What errors result from ignoring inter-sectoral flows of faculty, for example, movements between research and teaching institutions? By the end of our study, we will be in a position to answer some of these questions and to suggest ways of answering the rest.

Following Allan Cartter, a pioneer with this approach, we assume that age is the best predictor of when individuals advance in rank or leave academic employment. This "demographic approach" follows each age group (or "cohort") from its entry into academia until the end of our projection period in 1995, making extensive use of the simple identity that if

F(i,t) is the number of faculty of age i in year t, a(i,t) is the fraction of people of age i leaving academia between year t and t+1, and H(i,t) is the number of newly hired faculty during year t who are i years old (hired both to replace those who leave and to allow for expansion), then the number of faculty in year t+1 who are i+1 years old, F(i+1,t+1), can be expressed as:

$$F(i+1,t+1) = (1-a(i,t))F(i,t) + H(i,t) \quad .$$

In order to construct the series F(i,t), starting from a certain date, one need only know the series a(i,t) and H(i,t) . Lacking such knowledge, we can hypothesize values for the two sets of parameters and project the series F(i,t) conditional on these guesses. Demographers make a careful distinction between such a <u>projection</u>, which is a statement of the logical consequences of a set of assumptions, and a <u>forecast</u>, which is an unconditional prediction that a certain set of future events will occur. As Keyfitz [1977] has noted:

> A projection is bound to be correct, except when arithmetic errors make the numbers constituting its output inconsistent with the assumptions stated to be its input. On the other hand, a forecast is nearly certain to be wrong if it consists of a single number...A probability can--indeed, should--be attached to a forecast; whereas a probability is meaningless for a (hypothetical) projection.

Our strategy has been, then, to construct a large number of projections of junior faculty hiring, the tenure ratio, and the age structure of the total faculty, by varying the level of total faculty demanded by colleges, the age distribution of retirees and those who leave for non-academic jobs, and the rate (and hence the ages) at which junior faculty are given

tenure. We will be concentrating our attention on the sensitivity of our projections to these assumptions, leaving the forecasting to the reader.

Our projections are based on the observation that, conditional on age and years of experience in academia, the proportion who received tenure or who left academia in a given year is stable over time (or perhaps subject to a simple time trend). Hence knowing the number of faculty at each age in a given year allows us to predict quite accurately the number at each age in the subsequent year. However, the accuracy can be considerably improved by also controlling for the type of institution each faculty member is employed at and whether he is working full-time or part-time. To avoid unnecessary complications, in this paper we have chosen to restrict our attention to full-time doctorate faculty at four-year institutions. As a result, what we term "non-academic employment" includes employment in two-year colleges, and what we term "hires of new doctoral graduates" includes non-doctorate faculty who obtain a doctorate after starting their academic careers.

Reserving further discussion of the limitations of our methods and our data until later, we can report that the projections presented in detail in later sections of this paper reveal fairly robust patterns in the evolution of the age structure of doctorate faculty and the creation of new junior faculty positions:

(1) Under all of our projections, the level of hiring increases during the seventies and then declines during the eighties, bottoming out in 1985-86. The most "optimistic" projection of doctorate hiring for 1976 to 1995 is 155,000 people, or an average of 7750 people a year. In contrast, Cartter [1976] projected that between 1976 and 1990 there would be 568,000 new doctorates conferred.

(2) Although changes in the rate of retirement and out-migration and changes in the faculty-student ratio have sizable <u>percentage</u> impacts on the number of new junior faculty positions available, since the level of hiring is going to be very low during the rest of this century, <u>absolute</u> changes are small. Increasing the non-tenured quit rate leads to modest increases in hiring, but has very little impact on the tenure ratio or the age distribution; it reveals itself to be simply a "revolving door" policy. Increasing the tenured quit rate is much more effectual for keeping the tenure ratio low. Unfortunately, it is not clear how institutions can change their quit rates without encouraging the most gifted faculty from leaving first.

(3) Early retirement turns out to be disappointing. At most 1000 new junior faculty positions are created in any year by earlier retirement of the senior faculty. In addition, because early retirement has a quick "once and for all" impact on hiring, in order to have the most effective counter-cyclical impact on hiring it seems best to <u>delay</u> its implementation until 1990. Other policies must be relied on to smooth hiring in the 1980's.

(4) There is a continuous aging of faculty in every projection. By 1995 the median age of the doctorate faculty has increased by 8 to 11 years over its value of 41.7 in 1975. The percentage of faculty over the age of 50 increases from the current 24.6% to between 51.2% and 57.8%. Even when early retirement is assumed to have been instituted, the percentage of faculty in 1995 over the age of 50 is projected to be almost double its current level.

The remainder of this report is divided into five sections. The first section examines the effect of variations in the growth of enrollments. The second looks at the results of allowing the rate of promotion to fluctuate with excess demand (supply) of faculty, while the third examines the results of increasing the level of out-migration from academia by tenured and non-tenured faculty. We next examine the impact of the current elimination of mandatory retirement and the impact of programs which encourage faculty to retire earlier. The fifth section focuses on doctorate women and their future representation in academia. We end by summarizing our results and noting the extensions required of our methods and data to address the list of questions we discussed above. The appendices provide a careful derivation of our projection equations and a listing of the data we used to construct our probabilities.

2. Projecting Faculty Demand

The level of hiring of new doctorate faculty in any year is determined by the rate of attrition and changes in the level of doctorate employment at four-year institutions. Such changes reflect the interaction of many factors: changes in the desired faculty at each institution, changes in the budgetary conditions under which institutions translate these desires into actual hiring, changes in the level of non-academic demand for new and experienced doctorates, and changes in the number of new doctorates actively seeking employment in academia and changes in their preferences for teaching versus conducting research. In addition, because of field specialization, the aggregate level of academic employment results from equilibration of all the above factors in dozens of "field" sub-markets. Submarkets also exist geographically and by teaching-research inclination. Finally, doctorate faculty, who even at four-year institutions comprise only 50-55% of full-time faculty, compete with non-doctorate faculty for employment and promotion. Given this complexity, even if all of the data necessary were available, a "market based" approach to the determination of doctorate faculty would be a formidable undertaking, not made easier by other well-documented idiosycracies of the "academic market-place". We are not going to construct our projections of academic doctorate employment in such a sophisticated manner; instead, we will, equate changes in doctorate employment at four-year institutions with changes in demand.

Although since World War II research has become an increasingly important activity, most faculty are hired to teach. As a result, changes in student enrollments seem likely to have the greatest impact on changes

in the demand for faculty. In addition, if one considers the much greater accuracy with which we can project changes in enrollment, compared to changes in research funding, the assumption that faculty demand is determined by student enrollments is a reasonable approximation to reality. In the remainder of this paper we make the assumption that changes in the demand for doctorate faculty reflect changes in enrollments at four-year institutions. Now our task of projecting changes in faculty employment is greatly simplified. First we project changes in enrollments, and then we project the demand response of institutions to these enrollment changes.

We agree with Cartter [1976] that the primary source of the demand for doctorate faculty is degree-credit enrollment, since few faculty with doctorates teach non-degree courses at four-year colleges or universities. Cartter, for instance, puts the growth demand for doctorates resulting from increases in non-degree enrollment at less than 50 per year (Cartter [1976], p.111). Simple head counts of students also overestimate the demands on faculty time. Although the definition of "credit-hours" and the work required of a teacher with a given "teaching load" can vary over time and across schools, demand for teaching faculty is generally a function of the total credit-hours for which students enroll.[2] This means that part-time enrollments must be converted to "full-time equivalents" (FTE's) before we can use these numbers to project demand. U.S. Office of Education projections assume that 3 part-time students are equivalent to one full-time student, for a conversion factor of 0.33. The reader should keep in mind that FTE enrollments are simply a proxy for the total credit-hours for which students are enrolled. Should the ratio of enrolled credit-hours of full-time students

Table 2-1

PROJECTIONS OF FTE DEGREE-CREDIT ENROLLMENT AT ALL INSTITUTIONS [1]

YEAR	ENROLLMENT			CHANGE IN ENROLLMENT		
	NCES[2] (1977)	1973[3] (ALL)	CARTTER[4] (4-YEAR)	NCES[2] (1977)	1973[3] (ALL)	CARTTER[4] (4-YEAR)
1973	5729	6664	5423			
1974	7015	6754	5485	286	90	62
1975	7495	6909	5593	480	155	108
1976	7726	7063	5702	231	154	109
1977	7914	7225	5814	188	162	112
1978	8047	7390	5936	173	165	122
1979	8198	7548	6083	111	198	147
1980	8294	7765	6217	96	177	134
1981	8359	7861	6297	65	96	80
1982	8363	7906	6333	4	45	36
1983	8285	7857	6300	-78	-49	-33
1984	8135	7773	6244	-150	-84	-56
1985	7960	7623	6129	-175	-150	-115
1986		7476	6017		-147	-112
1987		7431	5982		-45	-35
1988		7461	6002		30	20
1989		7512	6036		51	34
1990		7418	5958		-94	-78

NOTES:

(1) Numbers in the table are in thousands

(2) This projection is for enrollments at both four-year and two-year institutions reported in The National Center for Educational Statistics [1976]. Numbers for the year 1973-76 are estimates.

(3) This is the projection for both four-year and two-year institutions in Cartter [1976], Table 5-8.

(4) This is Cartter's projection of enrollments for four-year institutions only, from Table 5-8.

to enrolled credit-hours of part-time students depart markedly from our presumed 3:1 ratio, then projections of "FTE enrollments" would become poor numbers from which to project demand for teaching faculty.

There are only two recent projections of FTE degree-credit enrollments known to this author.[3] The first is the series constructed by Cartter in his 1976 monograph (see his Table 5-8) and the second one is the N.C.E.S. series in Projections of Educational Statistics to 1985-86. Both series are listed in Table 2-1. Note that most of the differences between the two series are for the period 1973-77. After that, the increments projected are very similiar, though the N.C.E.S. is more pessimistic about the enrollment drop of the 1980s Unfortunately, the N.C.E.S. procedure of extrapolating curves fitted to past enrollment data does not seem reliable for horizons much longer than the ten years to which they restrict themselves. In contrast, Cartter begins with 1973 census projections of the number of 18-year-olds. After deciding on likely high school completion and college entrance rates, he then obtains projections of undergraduate first-time enrollments at four-year institutions. These he converts to FTE's by projecting the fraction of students enrolled part-time and employing an FTE conversion factor of 0.33. Cartter then assumes that total FTE degree-credit undergraduate enrollments are a weighted average of past first-time enrollments, which follows from assuming stable attrition rates. Finally, he adds to the series of undergraduate FTE enrollments his projections of FTE graduate and first-professional enrollments to obtain a projection of total FTE enrollments.

Unfortunately, the census has extensively revised its projections of the number of 18-year olds, particularly in the decade 1990-2000.

TABLE 2-2

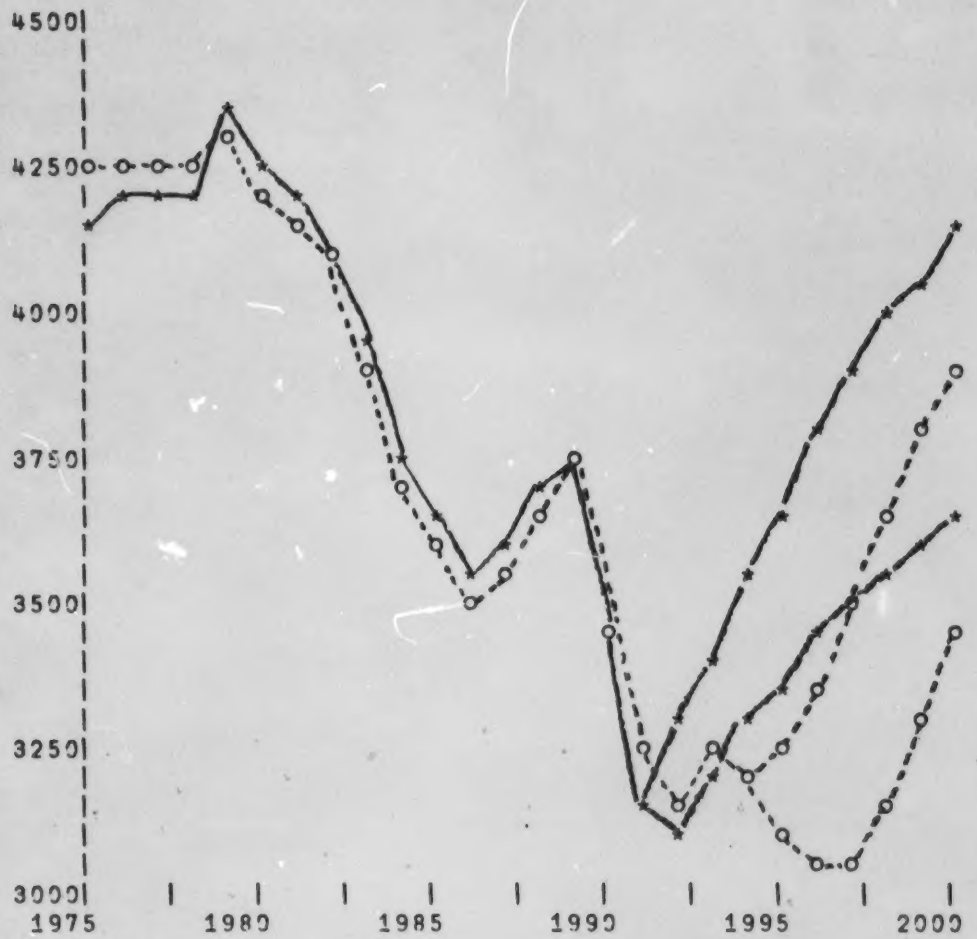
CENSUS PROJECTIONS OF THE NUMBER OF 18-YEAR OLDS
1975-2000
(IN THOUSANDS)

	NUMBER IN EACH YEAR				*CHANGE BETWEEN YEARS*			
	1973 *CENSUS PROJECTIONS*		1977 *CENSUS PROJECTIONS*		1973 *CENSUS PROJECTIONS*		1977 *CENSUS PROJECTIONS*	
YEAR	*SERIES E*	*SERIES F*	*SERIES II*	*SERIES III*	*SERIES E*	*SERIES F*	*SERIES II*	*SERIES III*
1975		4168		4245				
1976		4187		4254		19		9
1977		4204		4244		17		-10
1978		4207		4229		3		-15
1979		4344		4292		137		63
1980		4254		4211		-90		-81
1981		4182		4145		-72		-66
1982		4120		4087		-62		-58
1983		3945		3917		-175		-170
1984		3728		3703		-217		-214
1985		3625		3604		-103		-99
1986		3550		3521		-75		-83
1987		3597		3567		47		46
1988		3690		3653		93		86
1989		3735		3733		45		80
1990		3437		3426		-298		-307
1991		3143		3240		-294		-186
1992	3296	3108		3168	153	-35		-72
1993	3423	3198		3247	127	90		79
1994	3567	3282		3199	144	84		-48
1995	3668	3353	3262	3115	101	71	63	-84
1996	3783	3440	3359	3043	115	87	97	-72
1997	3892	3510	3491	3027	109	70	132	-16
1998	3982	3567	3652	3133	90	57	161	106
1999	4073	3624	3806	3301	91	57	154	168
2000	4140	3663	3911	3426	67	39	105	125

SOURCES:U.S. CENSUS, 'PROJECTIONS OF THE POPULATION OF THE U.S.: 1972-2000,' SERIES P-25, NO. 493, TABLE 2; U.S. CENSUS, 'PROJECTIONS OF THE POPULATION OF THE U.S.: 1977-2050,' SERIES P-25, NO. 704 (JULY 1977), TABLE 2.

FIGURE 2-3

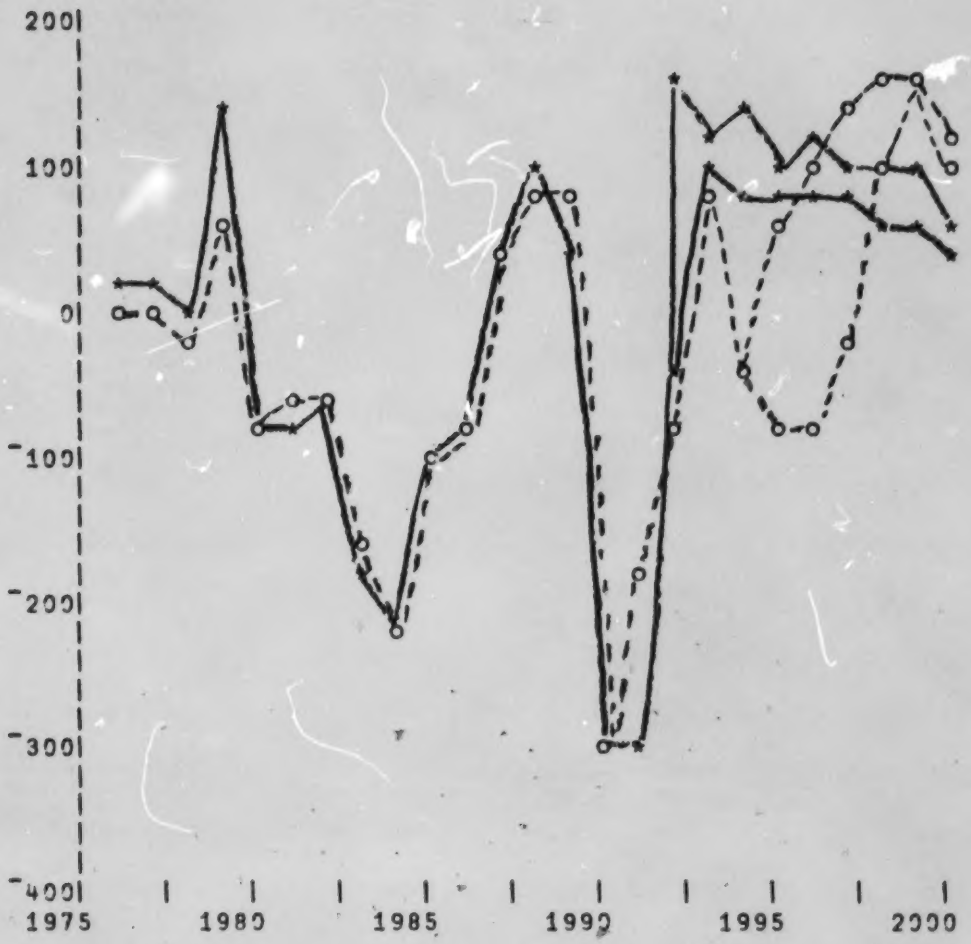
CENSUS PROJECTIONS OF THE NUMBER OF 18-YEAR OLDS: 1975-2000 (IN THOUSANDS)



★ - 1973 *CENSUS PROJECTIONS*
o - 1977 *CENSUS PROJECTIONS*

FIGURE 2-4

CENSUS PROJECTIONS OF THE YEARLY CHANGE IN THE NUMBER OF 18-YEAR OLDS:1976-2000 (IN THOUSANDS)



★ - 1973 *CENSUS PROJECTIONS*
○ - 1977 *CENSUS PROJECTIONS*

The new and old projections are shown in Table 2-2 and Figures 2-3 and 2-4. The census always presents a "high," "middle" and "low" projection, each being the consequence of different assumptions of the number of future births. Series E (in 1973) and II (in 1977) are "middle" projections, while series F and III are "low" ones. Notice that the 1973 "low" projections are now above the 1977 "middle" series-- at least until 1998. Since the late 1960s, the census has been continually revising its assumptions on completed fertility and the timing and spacing of children, and, as a consequence, continually revising downward its projections of births. As a result, we consider the projections after 1995 to be highly speculative, and probably biased upward. A final puzzling difference between the two census projections is the considerable revision downwards in the figures for 1976-1979; the average rate of growth in the size of this age group has been reduced from 44,000 to only 12,000 people a year.

Using the 1977 series II and all of Cartter's assumptions on future high school completion rates, college entrance rates, the fraction of part-time students, attrition rates, the fraction attending two-year institutions and the number of graduate students enrolled full-time and part-time, we have revised Cartter's enrollment projections. We will refer to this new series as our first <u>baseline</u> enrollment series. Although a natural alternative baseline series could be constructed from the census' series III, we believe this projection of the number of 18-year-olds is not "low enough". Consequently, our second baseline enrollment series was obtained from the first by holding enrollments <u>constant</u> after 1995, rather than allowing them to rise as series III implies. Our two baseline series are plotted in Figure 2-6, along with Cartter's original projection.

TABLE 2-5

PROJECTIONS OF FTE DEGREE-CREDIT ENROLLMENTS
USING 1977 CENSUS PROJECTIONS
(IN THOUSANDS)

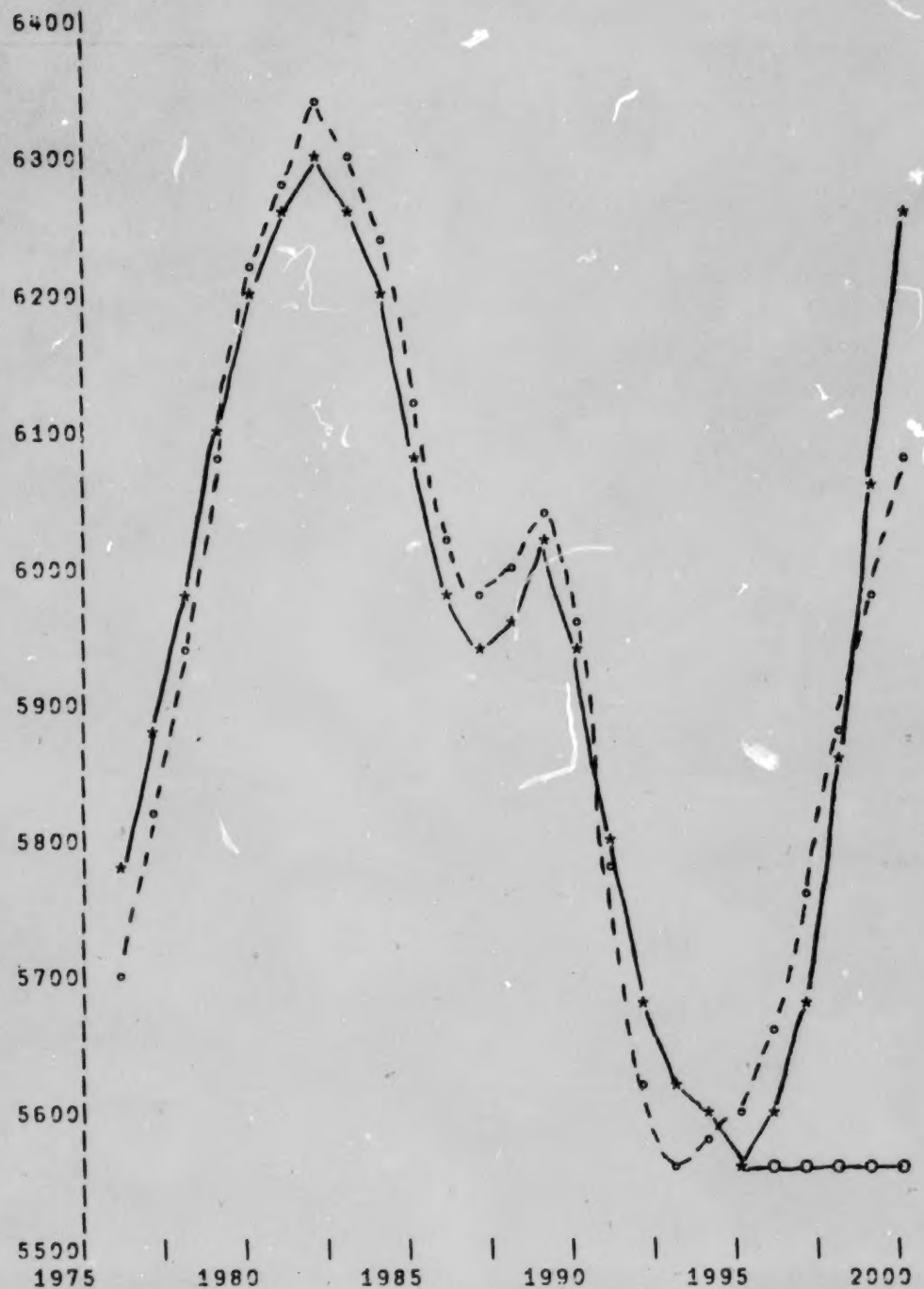
YEAR	NUMBER AGE 18	UG FIRST ENROL.	UG 4-YEAR ENROL.	GRADUATE + PROFESSIONAL	TOTAL FTE ENROLLMENTS	CARTTER (1973)
1976	4227	1700	4899	875	5774	5702
1977	4244	1724	5012	867	5879	5814
1978	4229	1745	5115	868	5983	5936
1979	4292	1797	5233	870	6103	6083
1980	4211	1789	5322	885	6207	6217
1981	4145	1782	5358	901	6259	6287
1982	4087	1778	5378	913	6291	6332
1983	3917	1724	5323	938	6261	6300
1984	3703	1648	5224	979	6203	6244
1985	3604	1620	5106	981	6087	6129
1986	3521	1597	4993	990	5983	6017
1987	3567	1632	4953	992	5945	5982
1988	3653	1683	4984	975	5959	6002
1989	3733	1731	5051	962	6013	6046
1990	3426	1600	5006	928	5934	5958
1991	3240	1520	4876	919	5795	5773
1992	3168	1494	4756	923	5679	5626
1993	3247	1538	4680	935	5615	5559
1994	3199	1522	4662	935	5597	5575
1995	3262	1556	4651	911	5562	5608
1996	3359	1604	4710	884	5594	5660
1997	3491	1669	4807	873	5680	5755
1998	3652	1754	4992	873	5865	5873
1999	3806	1827	5178	881	6059	5983
2000	3911	1883	5374	887	6261	6076

SOURCES:

1. NUMBER OF 18-YEAR OLDS: U.S. CENSUS, 'PROJECTIONS OF THE POPULATION OF THE U.S.: 1977-2050,' SERIES P-25, NO. 704 (JULY 1977), TABLE 2, SERIES II.
2. UNDERGRADUATE FIRST-YEAR AND TOTAL FTE ENROLLMENTS: CALCULATIONS OF THE AUTHOR; BASED ON CARTTER [1976], CHAPTER 4.
3. PROJECTED ENROLLMENTS OF GRADUATE STUDENTS: CARTTER [1976], TABLE 5-8.
4. CARTTER'S PROJECTIONS OF FTE ENROLLMENTS FROM 1990 TO 2000 WERE COMPUTED BY THE AUTHOR USING CARTTER [1976], TABLES THE PROJECTIONS FOR 1976-1990 ARE FROM TABLE 5-8.

FIGURE 2-6

BASELINE PROJECTIONS OF FTE ENROLLMENTS
1975-2000
(IN THOUSANDS)



★ - *BASELINE PROJECTION NO. 1*
○ - *BASELINE PROJECTION NO. 2*
• - *CARTTER'S PROJECTION USING 1973 CENSUS DATA*

Moving from enrollments to faculty demand is very difficult and has engaged various researchers. Freeman [1971], using time series, found an equation that "predicted" the student-faculty ratio fairly well. However, because he included the ratio, lagged one year, as a regressor variable, slow adjustment of the ratio over time could have accounted for his success. Radner and Miller [1975], using cross-sectional data on a sample of institutions for whom HEGIS data was available in 1966, found significant correlations between institution characteristics (i.e., the fraction of faculty with doctorates, the quality of the graduate program, and average faculty salary) and the student-faculty ratio. They note, however, that one cannot expect these relationships to stay constant over time. Though a series of cross-section estimates could be used to trace a trend, the HEGIS surveys are available for too few years to do this reliably. Even if we could accurately forecast the faculty-student ratios at individual institutions, we are not presently able to forecast enrollments at these institutions. Without such forecasts we cannot use the institutional ratios to calculate total faculty demand. We could proceed by assuming that the institutions retained their current share of total enrollments, but this ad hoc device nullifies our quest for accuracy in predicting total demand. It is possible to use cross-sectional data, but it is clearly too complicated and costly an approach for our purposes. We turn, instead, to a less econometric approach.

We showed above that enrollments are likely to contract during the entire period of 1982 to 1995. The factors that led to the current low faculty-student ratios will not likely hold during this period, in which

case, we can then expect an adjustment to a new value reflecting some new equilibrium. Hence, the change in the faculty-student ratio over the period might be approximately constant. U.S. Office of Education statistics as reported in Radner and Miller ([1975], p. 131) suggest that for the period 1950-1967 this is, in fact, what occurred. We regressed the reported faculty-student ratios (for the years 1953, 55, 56, 59, 63, 66, and 67) on a time trend, obtaining the results shown below. The fits are good enough to encourage us to proceed along this line. One problem in doing so, however, is lack of information on what trend we can expect to hold in the future, we cannot simply extrapolate from the past.

Table 2-7

Least squares coefficients of

faculty-student ratios as a function of time

$$F(t)/S(t) = a + b(t - 1952)$$

1953 - 1967

	Universities		4-Year Colleges	
	Public	Private	Public	Private
$\hat{a}$	.076	.081	.071	.081
$\hat{b}$	-.0010	+.0007	-.0011	-.0008
R^2	.744	.611	.935	.854

Source: U.S. Office of Education statistics from Radner and Miller [1975], p. 131.

Changes in the ratio of faculty with doctorates to students reflect changes in two ratios: changes in the ratio of doctorate faculty to total faculty, and changes in the ratio of total faculty to students. On the basis of the 1975 Carnegie Survey, we estimate that the number of full-time faculty with doctorates in four-year institutions is 188,561, while total faculty at four year institutions is 392,000. Using ratios of full-time to part-time faculty estimated for 1972 (Bayer [1973]), we estimate 1975 full-time faculty at 370,000. Hence the ratio of full-time faculty to FTE degree-credit students is .0613 (the inverse is 16.31) and the percentage of full-time faculty with doctorates is 50.5%. This compares with 47.3% that was estimated in 1967 (N.C.E.S. [1967]). Considering the estimated excess supply of potential junior faculty with the doctorate, it can be expected that this ratio will increase. Cartter believes 60% is probably the maximum value realizable. There is no reason to expect it to fall. The case with the student-faculty ratio is more speculative, since arguments can be made for it moving in either direction.

There is increasing evidence that, both in real terms and vis-a-vis other professionals, faculty salaries are declining. To the extent that the academic labor market operates classically, we can expect an increase in the "labor-intensity" of "academic production." That is, we can expect a higher faculty-student ratio. However, "student-buyers" do not purchase a homogenous good at a fixed price, but are offered heterogenous quality levels along with a variety of tuitions. A fall in labor costs to colleges would mean that competition (to the extent it is important) would lead to lower "quality-adjusted" tuitions. This can be achieved by lowering tuition but keeping student-faculty ratios constant or by raising the faculty-student ratio but keeping tuition constant. As a result, the employment consequences of lower (real) faculty salaries is uncertain. Complicating things further is the considerable (and growing) fraction of graduate and undergraduate students at public colleges and universities. The current budget cutbacks at these schools-- which shows no signs of ending-- are likely to lead to increased teaching loads and lower faculty-student ratios. Even if at private schools the trend is in the opposite direction, the aggregate result is uncertain. The movement towards faculty collective bargaining adds another dimension of uncertainty since this could alter both the current trend in relative faculty salaries, as well as the impact of this trend on teaching loads.

Uncertainty over the evolution of the faculty-student ratio makes any single projection of our model less than adequate for understanding the likely pattern of future hiring, tenure ratios and age distributions. The same problem will occur later when we consider the consequences of changes in our age-specific promotion probabilities and quit rates. The "solution" is to look at more than one projection and determine the degree to which our projections vary when we modify the assumptions on which they are constructed. If there is little variation, then we will refer to our projections as robust; if there is considerable variation, then we will call our projections sensitive. Taking a more sophisticated point of view, since our projections are functions (albeit complicated ones) of our set of assumptions, any a priori probability distribution we might assign to the assumptions would imply a probability distribution over the possible courses of evolution of academia. In this way, our projections can be used to create a forecast. Roughly speaking, robust projections will "usually" correspond to forecasts with small variances, while sensitive projections will "usually" correspond to forecasts that have large variances.

Our procedure will be to choose a set of "baseline" assumptions about future demand, quit rates, promotion rates and retirement rates, and then to vary each of them, one at a time, around the baseline values. A set of assumptions will be called a scenario. The baseline demand series is described below, the baseline promotion rates are constructed in section 3, the baseline quit rates are constructed in section 4, while the baseline retirement rates are discussed in section 5.

We have estimated that in 1975 there were 188,561 doctorate faculty at four-year institutions teaching 5,645,000 FTE degree-credit students.[4]

Across institutions, there was an average faculty-student ratio of 0.0334. Our baseline assumption is that this ratio does not change over the course of our projection period. Any change that did occur would have two possible sources: a change in the fraction of faculty with doctorates, or a change in the ratio of total (doctorate and non-doctorate) faculty to FTE students. We estimate that in 1975 these two figures were, respectively, 0.55 and 0.061. Table 2-8 below shows the different doctorate faculty-student ratios (DFSR) implied by given values of these two constituent variables. The table shows that an increasing DFSR is consistent with either a fall in the student-faculty ratio (the fraction of faculty with doctorates remaining constant) or with an increase in the fraction of faculty with doctorates (but with the ratio of students to total faculty remaining constant).

TABLE 2-8

Implied Doctorate Faculty-Student Ratio

		Fraction of faculty with doctorates		
		55%	65%	60%
Student-faculty Ratio	15.3	0.0326	0.0360	0.0392
	16.5	0.0303	0.0334	0.363
	18.3	0.0273	0.300	0.328

If the student-faculty ratio and the fraction of faculty with doctorates follow simple trends over the period, then so will the DFSR. Since an increase in the teaching load and an increase in the number of faculty

with extensive research training seem contradictory trends, Table 2-8 suggests that 0.036 and 0.030 are likely bounds on the DFRS. We will call the scenario: (A) "pro-cyclical" if the DFRS decreases to 0.030 by 2000, since the decline in hiring due to declining enrollments is exacerbated by this change; (B) "no change" or "baseline" if the ratio remains constant; and (C) "counter-cyclical" if the ratio increases to 0.036 by 2000, since, in this case, hiring is somewhat cushioned from the impact of declining enrollments.

In contrast to our procedure, Cartter projected faculty demand by assuming a constant <u>marginal</u> faculty-student ratio over the period. This means he assumed the increment in total faculty in any year is a constant fraction of the increment in FTE degree-credit enrollment. An objectionable feature of this assumption is that it implies that institutions react symmetrically to increases and decreases in enrollments. Because of tenure commitments, it is much more difficult for colleges to reduce their staffs than to increase them. Whatever the merits of his approach we can easily show that, over a period of oscillating enrollments, his assumption is inconsistent with any adjustment towards a "desired" ratio. Let S(t) = FTE degree-credit enrollment at time t; F(t) = full-time faculty at time t; $\Delta X(t)$ denotes $X(t)-X(t-1)$; then:

$$\Delta(F/S)(t) \simeq \frac{\Delta S(t)}{S(t)} \left[\frac{\Delta F(t)}{\Delta S(t)} - \frac{F(t)}{S(t)} \right] .$$

When $\Delta S(t)$ is positive and $\Delta F(t)/\Delta S(t)$ is constant $F(t)/S(t)$ moves toward $\Delta F/\Delta S$; but when $\Delta S(t)$ is negative, then $F(t)/S(t)$ moves away from $\Delta F/\Delta S$. As a result, the faculty-student ratio follows a cycle of the same periodicity as the cycle in enrollments. The net change in the faculty-student ratio over the period is close to zero. Furthermore, if the marginal ratio is generally higher than the average ratio, then the average ratio is increasing only when enrollments are increasing. If the marginal ratio is generally lower than the average, the average ratio increases only when enrollments decrease. These points are all demonstrated below in Table 2-9. We have chosen to work with the <u>student-faculty</u> ratio in order to make the numbers easier to grasp.

TABLE 2-9

Projected changes in the student-faculty ratio assuming a constant marginal ratio

	Alternative Value of $\Delta S/\Delta F$ over the period 1973-1990	
	15.0	20.0
Percentage change in enrollments in 1975	2.3%	2.3%
S/F in 1975	17.0	17.0
Δ(S/F) in 1975	-0.03	0.04
Percentage change in enrollments in 1986	-1.9%	-1.9%
S/F in 1986	16.7	17.3
Δ(S/F) in 1986	0.01	-0.02
% change in S/F between 1975 and 1995	-0.3%	1.3%

Source: Cartter [1976], Tables 5-8 and 6-7.

Our comments are intended not so much to criticize Cartter, as to underscore the point that the assumptions underlying our projections (as well as those by anyone else) can crucially affect the results obtained.

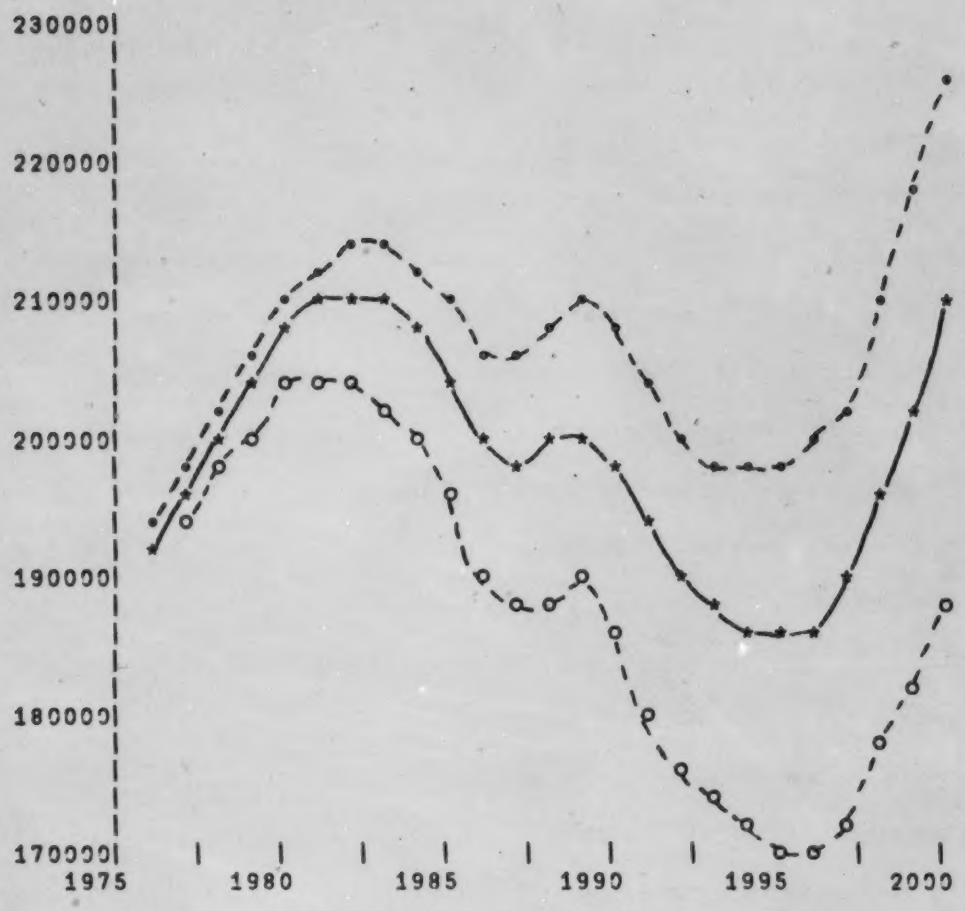
TABLE 2-10

ALTERNATIVE PROJECTIONS OF DOCTORATE FACULTY DEMAND
1976-2000

YEAR	PROJECTED ENROLLMENTS (BASELINE 1)	CHANGE IN DEMAND FOR FULL-TIME FACULTY			TOTAL FULL-TIME FACULTY		
		PRO-CYCLICAL	NO CHANGE (BASELINE)	COUNTER-CYCLICAL	PRO-CYCLICAL	NO CHANGE (BASELINE)	COUNTER-CYCLICAL
1976	5774000	3491	4276	4877	192052	192837	193438
1977	5880000	2708	3521	4144	194760	196359	197582
1978	5984000	2640	3482	4126	197400	199841	201708
1979	6104000	3127	4006	4678	200527	203847	206386
1980	6207000	2557	3458	4146	203084	207305	210532
1981	6259000	853	1740	2418	203937	209045	212950
1982	6292000	199	1081	1756	204137	210126	214706
1983	6262000	-1821	-998	-369	202315	209128	214337
1984	6201000	-2731	-1951	-1355	199584	207176	212982
1985	6063000	-4555	-3869	-3344	195029	203307	209638
1986	5983000	-4148	-3476	-2962	190881	199831	206676
1987	5946000	-2016	-1264	-689	188865	198567	205987
1988	5960000	-368	465	1102	188497	199033	207089
1989	6013000	882	1795	2493	189379	200828	209582
1990	5934000	-3295	-2638	-2136	186084	198189	207446
1991	5796000	-5127	-4621	-4234	180958	193568	203212
1992	5679000	-4414	-3895	-3498	176544	189674	199714
1993	5616000	-2737	-2120	-1648	173807	187553	198065
1994	5597000	-1335	-619	-71	172472	186935	197994
1995	5563000	-1827	-1161	-651	170645	185774	197343
1996	5595000	226	1074	1723	170871	186848	199066
1997	5681000	1853	2871	3650	172724	189720	202716
1998	5865000	4817	6168	7200	177542	195887	209916
1999	6059000	5046	6477	7571	182588	202364	217487
2000	6261000	5240	6751	7907	187828	209115	225394

NOTES:
1. THE 'PRO-CYCLICAL' PROJECTION ASSUMES THAT THE FACULTY-STUDENT RATIO DECLINES FROM 0.033 TO 0.027; THE 'NO CHANGE' OR 'BASELINE' PROJECTION ASSUMES THAT THE RATIO REMAINS CONSTANT; THE 'COUNTER-CYCLICAL' PROJECTION ASSUMES THAT THE RATIO INCREASES FROM 0.033 TO 0.039
2. PROJECTED ENROLLMENTS ARE FROM TABLE 2-5.

FIGURE 2-11
ALTERNATIVE PROJECTIONS OF DOCTORATE FACULTY DEMAND: 1976-2000



o - 'PRO-CYCLICAL' PROJECTION (FALLING FACULTY-STUDENT RATIO)
* - 'NO CHANGE' OR BASELINE PROJECTION (CONSTANT FACULTY-STUDENT RATI
• - 'COUNTER-CYCLICAL' PROJECTION (RISING FACULTY-STUDENT RATIO)

Figure 2-11 shows that demand under all three scenarios has the same pattern of an increase in demand during the 1970s, a downturn in the early 1980s, a short plateau in the late 1980s, a very large downturn in the early and mid 1990s, followed by a sharp upturn in the late 1990s. If we ignore the small upturn in 1988-89, demand declines constantly from 1981-83 until 1995-96, a period of about 14 years! Furthermore, if the population-induced increase in enrollments in the late 1990s fails to materialize, then the "academic depression" could extend until the year 2000 and beyond. As a consequence, any programs designed to increase hiring must be long-lived in order to be effective. Any policy pursued by institutions to increase faculty turn-over must have more than a transitory impact. As an example, inducing faculty to retire early has primarily a transitory effect, and hence, will not noticably help curb the fall in hiring. We will return to this point in Section 5.

Under each of our three scenarios we have projected the evolution of doctorate faculty from 1976 to 2000. Our model, which is described in detail in an appendix to this report, provides us with projections of doctorate hiring, the tenure ratio, the age distribution and attrition rates of tenured and non-tenured facutly, and the mean rate of promotion to tenure. Our results are reported in Tables 2-16 through 2-21, at the end of this section. The most striking results, summarized in Figures 2-12 and 2-13, are the large increases in the tenure ratio and the swift aging of the faculty obtained under all three scenarios.

FIGURE 2-12

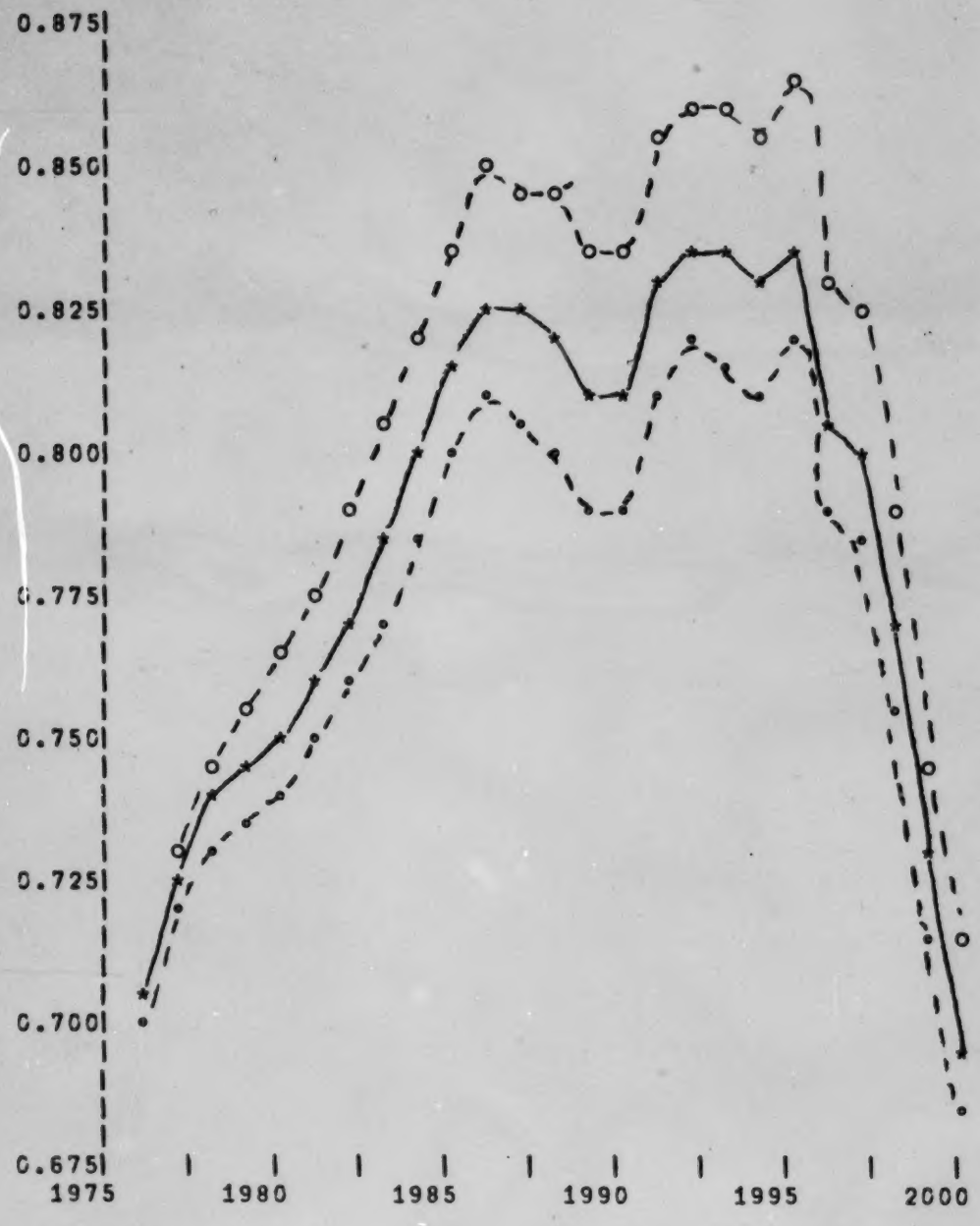
PROJECTIONS OF MEDIAN AGES OF TENURED AND NON-TENURED FACULTY: 1976-2000 ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND

o - *PRO-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*
* - *NO VARIATION IN FACULTY-STUDENT RATIO (BASELINE)*
• - *COUNTER-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*

THE UPPER THREE PLOTS ARE TENURED FACULTY, WHILE THE LOWER THREE PLOTS ARE THE NON-TENURED FACULTY

FIGURE 2-13

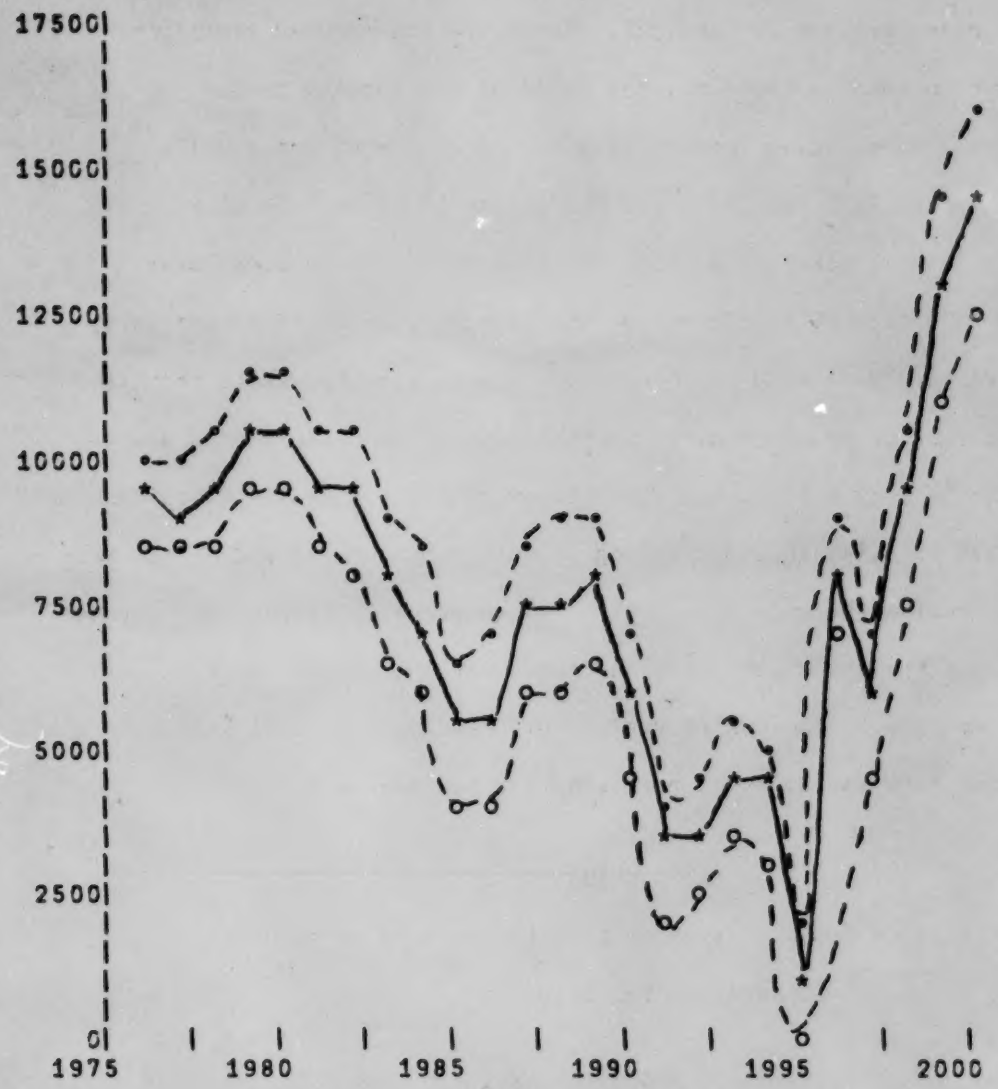
PROJECTIONS OF THE TENURE RATIO
ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND



o - *PRO-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*
* - *NO VARIATION IN FACULTY-STUDENT RATIO (BASELINE)*
• - *COUNTER-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*

FIGURE 2-14

PROJECTIONS OF NEW DOCTORATES HIRES
ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND



o - *PRO-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*
* - *NO VARIATION IN FACULTY-STUDENT RATIO (BASELINE)*
• - *COUNTER-CYCLICAL VARIATION IN FACULTY-STUDENT RATIO*

By 1995, the last year of declining faculty demand, the tenure ratio has increased between 18 and 23%, while the median age of doctorate faculty has risen between 20 and 25%. Since the non-tenured faculty's age distribution remains constant, the aging of the faculty is due almost entirely to an aging tenured faculty. A glance at Table 2-17 shows that between 1976 and 1995, the median age of tenured faculty increases by 8 to 10 years. Although the promotion rate is much lower during 1980-1995 than it is currently, the immediate cause of both developments is the rapidly falling number of non-tenured faculty, which results in a smaller flow of young faculty into the tenured ranks. This is demonstrated in Table 2-15 below. The flow of newly-tenured faculty drops from 11,508 in 1976 to 3,747 in 1985, rising to only 6,064 by the end of the century. Although increasing the rate of promotion to tenure will temper the increase in the "age gap" between those with and those without tenure, it will only exacerbate the rise in the tenure ratio. Ultimately, this will lead to a lower turnover rate and to fewer positions for new doctorates.

TABLE 2-15

The Flow of Young Doctorates into the Tenured Ranks

(Baseline Projection)

Year	Non-tenured Faculty	Promotion Rate	Newly Tenured Faculty
1976	59,019	0.193	11,508
1980	49,948	0.135	6742
1985	36,383	0.103	3747
1990	36,853	0.117	4312
1995	32,317	0.135	4362
2000	61,256	0.099	6064

The cause of this decline in the number of non-tenured faculty is simply the very low levels of hiring projected. Figure 2-14 shows that between 1983 and 1998, under the baseline scenario, an average of 6,400 new doctorates are hired each year, compared to the 10,400 that is projected for 1978 and the average of 10,800 hired in each year during the "academic boom" of 1961-70 (Cartter [1976],p.143). The pro-cyclical scenario implies a hiring level about 20% below the baseline, while the counter-cyclical scenario puts hiring at about 18% above the baseline. Hires of new doctorates is mildly sensitive to the assumed faculty-student ratio. The worst year is 1995 when doctorate hiring is projected to be less than 3200; under the pro-cyclical scenario, hiring is almost zero.

Since our figures are aggregated over all four-year institutions, most institutions must be decreasing their staffs. Non-tenured faculty being the most vulnerable group, we would expect the quit rate for non-tenured faculty to increase. On the basis of Radner and Kuh [1978], in a period of declining demand we can expect junior faculty to remain untenured longer. This phenomenon appears to be an aspect of the process of equilibration in the academic markets. In addition, as colleges see their tenure ratios soar, they may respond with tenure quotas, further reducing promotions. Finally, falling starting salaries will probably affect the whole salary structure, inducing some of the tenured faculty to seek and find non-academic positions. All three of these responses to the declining demand for doctorates have been incorporated into our baseline assumptions. That is, we have already incorporated some "feed-back" from projected hiring into our model. Without it, the projections we obtained above would have been much more extreme. However, this endogeneity needs to be explored in more detail, which we will do in the next three sections.

TABLE 2-16

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROJECTIONS OF DOCTORATE DEMAND

YEAR		TOTAL FACULTY AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	1	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.014
	2	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.014
	3	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.014
1980	1	0.064	0.188	0.359	0.541	0.694	0.832	0.927	0.987	1.000	43.9	0.031
	2	0.070	0.199	0.369	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.032
	3	0.074	0.208	0.377	0.556	0.704	0.838	0.930	0.987	1.000	43.4	0.032
1985	1	0.038	0.135	0.253	0.423	0.596	0.756	0.895	0.980	1.000	47.1	0.039
	2	0.046	0.154	0.276	0.443	0.612	0.766	0.899	0.980	1.000	46.6	0.041
	3	0.051	0.168	0.293	0.458	0.623	0.773	0.902	0.981	1.000	46.2	0.042
1990	1	0.043	0.124	0.219	0.337	0.500	0.681	0.843	0.969	1.000	50.0	0.036
	2	0.051	0.145	0.249	0.370	0.528	0.699	0.853	0.971	1.000	49.2	0.037
	3	0.056	0.159	0.270	0.393	0.546	0.712	0.859	0.972	1.000	48.5	0.037
1995	1	0.028	0.109	0.196	0.299	0.422	0.602	0.794	0.950	1.000	52.3	0.034
	2	0.034	0.128	0.227	0.339	0.461	0.632	0.810	0.954	1.000	51.3	0.033
	3	0.039	0.140	0.248	0.365	0.488	0.651	0.821	0.956	1.000	50.4	0.032
2000	1	0.085	0.218	0.324	0.419	0.514	0.628	0.789	0.944	1.000	49.3	0.037
	2	0.089	0.229	0.344	0.448	0.548	0.660	0.809	0.949	1.000	47.6	0.035
	3	0.092	0.236	0.357	0.467	0.569	0.681	0.822	0.953	1.000	46.6	0.034

NOTES;

1. *PROJECTION 1 ASSUMES THAT THE FACULTY-STUDENT RATIO DECLINES OVER THE PERIOD. PROJECTION 2 ASSUMES THE RATIO REMAINS CONSTANT. PROJECTION 3 ASSUMES TAHT THE RATIO INCREASES OVER THE PERIOD.*

TABLE 2-17

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROJECTIONS OF DOCTORATE DEMAND

YEAR		TENURED FACULTY AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	1	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.005
	2	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.005
	3	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.005
1980	1	0.005	0.063	0.228	0.435	0.623	0.792	0.911	0.986	1.000	46.6	0.019
	2	0.005	0.064	0.229	0.436	0.624	0.793	0.911	0.986	1.000	46.5	0.018
	3	0.006	0.066	0.231	0.438	0.625	0.793	0.911	0.986	1.000	46.5	0.018
1985	1	0.003	0.046	0.148	0.331	0.530	0.715	0.877	0.977	1.000	49.2	0.024
	2	0.003	0.051	0.157	0.340	0.537	0.720	0.879	0.977	1.000	49.0	0.023
	3	0.004	0.055	0.164	0.347	0.542	0.723	0.881	0.977	1.000	48.8	0.023
1990	1	0.003	0.028	0.103	0.225	0.413	0.623	0.815	0.964	1.000	52.1	0.027
	2	0.003	0.033	0.117	0.244	0.429	0.634	0.821	0.965	1.000	51.7	0.026
	3	0.004	0.037	0.126	0.257	0.441	0.643	0.825	0.966	1.000	51.5	0.026
1995	1	0.002	0.029	0.092	0.194	0.329	0.535	0.759	0.941	1.000	54.2	0.034
	2	0.002	0.035	0.108	0.220	0.359	0.558	0.772	0.945	1.000	53.7	0.032
	3	0.002	0.039	0.119	0.239	0.380	0.574	0.781	0.947	1.000	53.2	0.031
2000	1	0.004	0.044	0.122	0.220	0.339	0.490	0.710	0.923	1.000	55.3	0.036
	2	0.005	0.048	0.136	0.246	0.373	0.525	0.732	0.929	1.000	54.3	0.033
	3	0.005	0.050	0.145	0.264	0.396	0.548	0.747	0.933	1.000	53.6	0.031

NOTES:

1. *PROJECTION 1 ASSUMES THAT THE FACULTY-STUDENT RATIO DECLINES OVER THE PERIOD. PROJECTION 2 ASSUMES THE RATIO REMAINS CONSTANT. PROJECTION 3 ASSUMES TAHT THE RATIO INCREASES OVER THE PERIOD.*

TABLE 2-18

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROJECTIONS OF DOCTORATE DEMAND

YEAR		NON-TENURED FACULTY AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	1	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	2	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	3	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
1980	1	0.265	0.611	0.801	0.900	0.934	0.969	0.984	0.991	1.000	33.2	0.073
	2	0.274	0.625	0.810	0.906	0.939	0.971	0.985	0.991	1.000	33.0	0.073
	3	0.280	0.634	0.815	0.910	0.942	0.973	0.986	0.992	1.000	32.9	0.074
1985	1	0.226	0.608	0.809	0.905	0.947	0.972	0.987	0.995	1.000	33.5	0.120
	2	0.242	0.628	0.823	0.915	0.954	0.976	0.989	0.996	1.000	33.2	0.121
	3	0.251	0.639	0.831	0.921	0.958	0.979	0.990	0.996	1.000	33.0	0.122
1990	1	0.251	0.620	0.817	0.914	0.953	0.980	0.989	0.996	1.000	33.2	0.083
	2	0.258	0.634	0.829	0.922	0.959	0.984	0.991	0.997	1.000	33.0	0.083
	3	0.262	0.641	0.835	0.927	0.962	0.985	0.992	0.997	1.000	32.9	0.084
1995	1	0.177	0.557	0.783	0.893	0.942	0.977	0.990	0.995	1.000	34.2	0.036
	2	0.188	0.569	0.794	0.901	0.948	0.981	0.992	0.996	1.000	34.0	0.036
	3	0.194	0.575	0.799	0.905	0.951	0.982	0.993	0.997	1.000	34.0	0.036
2000	1	0.294	0.671	0.848	0.935	0.968	0.988	0.995	0.998	1.000	32.5	0.039
	2	0.292	0.668	0.846	0.935	0.968	0.988	0.995	0.998	1.000	32.5	0.039
	3	0.292	0.666	0.845	0.935	0.968	0.988	0.995	0.999	1.000	32.6	0.039

NOTES:

1. *PROJECTION 1 ASSUMES THAT THE FACULTY-STUDENT RATIO DECLINES OVER THE PERIOD. PROJECTION 2 ASSUMES THE RATIO REMAINS CONSTANT. PROJECTION 3 ASSUMES TAHT THE RATIO INCREASES OVER THE PERIOD.*

TABLE 2-19
PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND

OTHER STATISTICS

		1976	1980	1985	1990	1995	2000
TENURE	1	0.687	0.775	0.845	0.844	0.847	0.721
RATIO	2	0.687	0.763	0.825	0.820	0.823	0.706
	3	0.687	0.754	0.811	0.803	0.807	0.697
PROMOTION	1	0.193	0.138	0.115	0.125	0.125	0.099
RATE	2	0.193	0.135	0.111	0.123	0.121	0.100
	3	0.193	0.133	0.109	0.122	0.119	0.100
TURNOVER	1	0.046	0.047	0.021	0.024	0.000	0.066
RATE	2	0.049	0.052	0.028	0.029	0.006	0.069
	3	0.053	0.055	0.032	0.033	0.010	0.071
TOTAL	1	188561	203084	195029	186084	170645	187828
FACULTY	2	188561	207255	203258	198142	185729	209065
	3	188561	210532	209638	207446	197343	225394

NOTES:

1. *PROJECTION 1 ASSUMES THAT THE FACULTY-STUDENT RATIO DECLINES OVER THE PERIOD. PROJECTION 2 ASSUMES THE RATIO REMAINS CONSTANT. PROJECTION 3 ASSUMES TAHT THE RATIO INCREASES OVER THE PERIOD.*

2. *THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.*

TABLE 2-20

PROJECTIONS OF NEW DOCTORATES HIRED ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND

YEAR	PRO-CYCLICAL	NO CHANGE (BASELINE)	COUNTER-CYCLICAL
1976	-7.9	9327	6.9
1977	-9.3	9222	7.2
1978	-9.8	9633	7.6
1979	-9.9	10642	7.6
1980	-10.8	10698	8.3
1981	-13.0	9488	10.0
1982	-14.2	9294	10.9
1983	-17.5	7790	13.4
1984	-19.7	7197	15.1
1985	-25.5	5609	19.5
1986	-25.7	5661	19.7
1987	-20.8	7315	15.9
1988	-17.9	8852	13.7
1989	-16.1	10170	12.3
1990	-23.1	5817	17.7
1991	-33.3	3351	25.5
1992	-29.9	3542	22.9
1993	-21.6	5073	16.6
1994	-17.6	6473	13.4
1995	-17.2	5960	13.2
1996	-14.6	8319	11.2
1997	-13.3	10482	10.2
1998	-12.3	14153	9.5
1999	-12.5	14960	9.6
2000	-12.6	15709	9.7

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 2-21

PROJECTIONS OF THE TENURE RATIO
ASSUMING ALTERNATIVE PROJECTIONS OF FACULTY DEMAND

YEAR	*PRO-CYCLICAL*	*NO CHANGE (BASELINE)*	*COUNTER-CYCLICAL*
1976	0.4	0.703	-0.3
1977	0.8	0.724	-0.6
1978	1.2	0.738	-0.9
1979	1.5	0.745	-1.1
1980	1.7	0.751	-1.3
1981	2.0	0.762	-1.4
1982	2.1	0.772	-1.6
1983	2.3	0.786	-1.7
1984	2.4	0.799	-1.8
1985	2.6	0.814	-1.9
1986	2.8	0.825	-2.0
1987	3.0	0.823	-2.1
1988	3.1	0.813	-2.2
1989	3.2	0.800	-2.2
1990	3.1	0.807	-2.2
1991	3.1	0.825	-2.1
1992	3.1	0.833	-2.1
1993	3.2	0.829	-2.1
1994	3.2	0.817	-2.1
1995	3.1	0.810	-2.0
1996	2.9	0.796	-1.9
1997	2.7	0.773	-1.8
1998	2.5	0.738	-1.6
1999	2.3	0.706	-1.5
2000	2.1	0.678	-1.3

NOTES:
1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

3. Promotion Rates

Our approach in this paper is to assume age-specific promotion rates. The primary reason for this assumption is that most non-tenured faculty in any given year are not awaiting a tenure decision but are serving an "apprenticeship period." Therefore the probability of being promoted is the product of the probability of being under tenure review (a function of one's academic age) and the probability of being granted tenure given one is reviewed (the point at which market pressure impinges). Even in a "boom" period where the second probability is rising, a large influx of new junior faculty could lead to the mean promotion rate falling. For the purposes of this study we have taken the following specification of our promotion probabilities, ϕ_{it} :

$$\phi_{it} = \frac{A_i B_t}{1 + A_i B_t} ,$$

where i = age in academia and t = date .

Using survey data on full-time doctorate faculty collected by the Carnegie Commission in 1975, the "age effects" (A_i) and "date effects" (B_t) were estimated for the period 1926 to 1974 (Radner and Kuh [1977]). The appendix to this report has a longer discussion of the estimation procedure, and the way we constructed the age effects for use in our projections. The question before us is how to project the date effects

to 2000, and thus project the promotion probabilities, assuming the age effects remain constant over our projection period.

Although higher promotion rates could be a way for institutions to compete for junior faculty, to be successful such a strategy requires that changes in these rates be communicated quickly and that current promotion rates be taken as good signals of future rates. Neither is likely to occur. More likely is for promotion rates to respond to the demand for experienced faculty. In a period when rising demand for doctorate faculty outstrips the supply of new doctorates from graduate schools, demand for experienced faculty would rise as institutions try to maintain student-doctorate faculty ratios. Hence there should be a relationship not only between the estimated date effects and enrollment changes but between the date effects and the number of new doctorates as well. This relationship probably has a complex and shifting lag structure, since many institutions have the option of maintaining their faculty-student ratios by rationing enrollments. The first impact of increased enrollments would be on the flows of new undergraduates to various types and qualities of colleges; many institutions would see only small changes in their faculty-student ratios though the mean ratio fell substantially. Over time, though, they would see the opportunity to expand and would increase their faculty to accommodate higher enrollments. The larger the unexpected increase in enrollments, the longer the time before faculty hiring responded, an expectation supported by simple statistical analysis we have done.

We proceeded to regress our estimated date effects, B_t , on changes in degree-credit enrollment and new doctoral degrees conferred. Over the period 1954 to 1974, for which we had consistent data series, no relationships provided consistently good fits. Although two different

equations gave good fits for two sub-periods, 1954 to 1964 and 1967 to 1973, they both imply that, when enrollments are steadily falling, increases in the number of doctorates conferred result in <u>higher</u> promotion rates two to four years later.[5] As we would expect that increases in the number of new doctorates seeking employment would always lead, <u>ceteris parabus</u>, to <u>lower</u> rates of promotion to tenure, neither equation can be expected to predict well during the forthcoming period of contracting enrollments.

As a result, we decided to simply assume that:

$$\ell n\ B_t = a + b\ E_{t-2} + c\ D_{t-2}\ ,$$

where B_t is the date effect of the promotion rates at time t, E_{t-2} is the change in degree-credit enrollment two years earlier, D_{t-2} is the number of doctorates conferred two years earlier, and $b \geq 0$, while $c \leq 0$. We then searched for a pair (b,c) that provided an equation which consistently over-predicted B_t over the period 1954-74, a pair that led to consistent under-estimation of B_t, and a pair that led to almost no change in B_t over the projection period. The three equations are:

1) "high promotions:" $\ell n\ B_t = C_1 + 0.001\ E_{t-2} - 0.001\ D_{t-2}$,

2) "medium promotions:" $\ell n\ B_t = C_2 + 0.00277\ E_{t-2} - 0.00389\ D_{t-2}$, and

3) "low promotions:" $\ell n\ B_t = C_3 + 0.00577\ E_{t-2} - 0.00973\ D_{t-2}$.

TABLE 3-1

ENROLLMENTS AND NEW DOCTORATES: 1954-1998

YEAR	ENROLLMENT INCREMENTS (ACTUAL)	NEW DOCTORATES	YEAR	ENROLLMENT INCREMENTS (PROJECTIONS)	NEW DOCTORATES
1954	20000	3000	1976	127000	36600
1955	186000	8800	1977	106000	37400
1956	229000	8900	1978	104000	39100
1957	1563000	8800	1979	120000	40600
1958	175000	8900	1980	103000	42000
1959	63000	9300	1981	52000	42400
1960	167000	9800	1982	33000	43200
1961	213000	10600	1983	-30000	43100
1962	244000	11600	1984	-59000	42100
1963	44000	12800	1985	-115000	40200
1964	616000	14500	1986	-105000	38000
1965	446000	16500	1987	-37000	34800
1966	386000	18200	1988	14000	34800
1967	64000	20600	1989	53000	35500
1968	519000	23100	1990	-79000	37600
1969	266000	26200	1991	-138000	39500
1970	334000	29900	1992	-117000	41000
1971	101000	32100	1993	-63000	42000
1972	83000	33400	1994	-19000	43000
1973	173000	34400	1995	-34000	44000
1974	178000	34600	1996	32000	45000
1975	146000	35800	1997	86000	45000
			1998	184000	45000

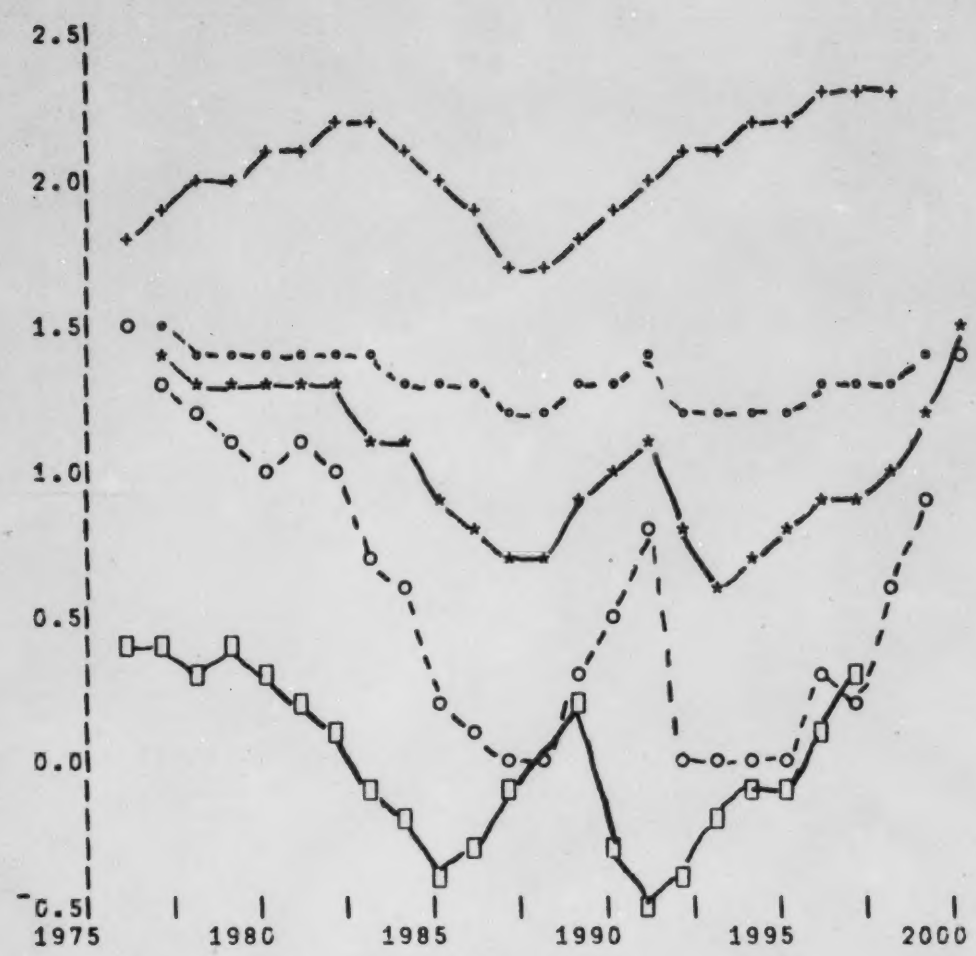
SOURCES:

1. *INCREMENTS IN FTE DEGREE-CREDIT ENROLLMENTS*, 1954-1974, *ARE TAKEN FROM THE* <u>*BIENNIAL SURVEY OF HIGHER EDUCATION*</u> *AND* <u>*PROJECTIONS OF EDUCATIONAL STATISTICS*</u>. *VARIOUS ISSUES; BOTH ARE N.C.E.S. PUBLICATIONS. PROJECTIONS FOR* 1976-1998 *ARE TAKEN FROM TABLE* 2-10.

2. *NEW DOCTORATES*, 1954-1960, *ARE FROM* <u>*EARNED DEGREES CONFERRED*</u>, 1964-65, *OFFICE OF EDUCATION, TABLE* 4. *FIGURES FOR* 1961-1990 *ARE FROM CARTTER* [1976], *TABLE* 5-5. *PROJECTIONS FOR* 1991-1998 *ARE THE AUTHOR'S EXTRAPOLATIONS OF CARTTER'S SERIES.*

FIGURE 3-2

ALTERNATIVE PROJECTIONS OF THE 'DATE EFFECTS' OF THE RATES OF PROMOTION TO TENURE
1976-2000



• - *PROJECTION USING THE 'HIGH PROMOTION' EQUATION*
★ - *PROJECTION USING THE 'BASELINE' EQUATION*
○ - *PROJECTION USING THE 'LOW PROMOTION' EQUATION*
□ - *BASELINE PROJECTION OF FTE ENROLLMENT INCREMENTS THE SCALE IS* 1= 300,000.
\+ - *BASELINE PROJECTION OF NEW DOCTORATES (CARTTER* [1976]) *THE SCALE IS* 1= 20,000.

TABLE 3-3

	DATE EFFECTS			STANDARDIZED PROMOTIONS RATES		
YEAR	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
1976	1.495	1.495	1.495	0.192	0.192	0.192
1977	1.462	1.402	1.300	0.189	0.182	0.172
1978	1.442	1.346	1.181	0.187	0.177	0.160
1979	1.420	1.284	1.052	0.184	0.170	0.146
1980	1.416	1.272	1.024	0.184	0.169	0.142
1981	1.431	1.311	1.102	0.185	0.173	0.151
1982	1.412	1.258	0.990	0.183	0.168	0.139
1983	1.361	1.115	0.692	0.178	0.153	0.102
1984	1.341	1.060	0.574	0.176	0.147	0.086
1985	1.278	0.885	0.212	0.170	0.126	0.033
1986	1.250	0.809	0.054	0.167	0.117	0.009
1987	1.196	0.661	0.000	0.161	0.098	0.000
1988	1.208	0.697	0.000	0.163	0.103	0.000
1989	1.279	0.898	0.252	0.170	0.128	0.039
1990	1.330	1.040	0.546	0.175	0.148	0.082
1991	1.369	1.145	0.765	0.179	0.156	0.111
1992	1.235	0.771	0.000	0.165	0.112	0.000
1993	1.174	0.600	0.000	0.159	0.090	0.000
1994	1.193	0.653	0.000	0.161	0.097	0.000
1995	1.246	0.798	0.032	0.167	0.116	0.005
1996	1.289	0.916	0.276	0.171	0.130	0.043
1997	1.273	0.871	0.180	0.169	0.124	0.028
1998	1.338	1.050	0.551	0.176	0.145	0.083
1999	1.392	1.199	0.863	0.181	0.162	0.123
2000	1.490	1.471	1.428	0.192	0.190	0.185

SOURCE: AUTHOR'S CALCULATIONS.

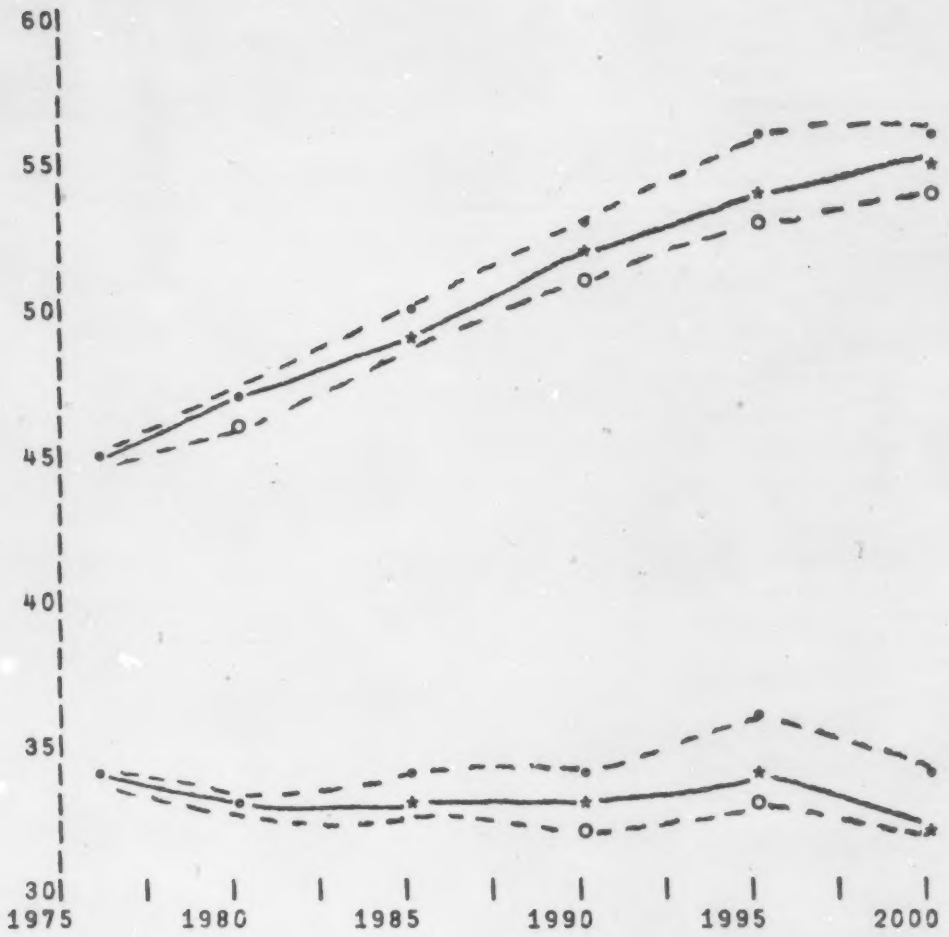
The constants C_1, C_2, and C_3 have been adjusted so that all three equations agreed in 1975 with the date effect estimated for that year by Radner and Kuh. In table 3-1 estimates of enrollments and new doctorates conferred for the years 1954 to 1975 are listed along with projections to the year 1998. Figure 3-2 plots these projections along with the three series of date effects we have calculated using the equations above. Since each date effect represents a family of age-specific promotion probabilities, a more easily interpretable function of the date effect is the mean promotion rate implied by these promotion probabilities and a given age distribution of non-tenured faculty. We will refer to this as the standardized promotion rate of each date effect. Table 3-3 lists the three series of date effects along with their standardized promotion rates. In 1989 and 1993-95 the "low promotion" equation "predicts" negative date effects. Since this is not defined, we have set such values to zero. A zero value for the date effect implies no promotions to tenure in that year. The reader may consider such an event highly unlikely, yet no other lower bound suggests itself.

The three series of promotion probabilities provide us with three scenarios: a "low promotion" scenario, a "medium promotion" or "baseline" scenario, and "high promotion" scenario. In all three scenarios we assume the baseline projections of faculty demand and attrition. The resulting projections are summarized in Figures 3-4, 3-5 and 3-6, and displayed in detail in Tables 3-9 through 3-14 at the end of this section.

Predictably, a low rate of promotion to tenure, by reducing the flow of young faculty into the tenured ranks and holding faculty longer in the non-tenured ranks, results in higher median ages than is observed under the baseline scenario. However, the difference is rather small,

FIGURE 3-4

PROJECTIONS OF MEDIAN AGES OF TENURED AND NON-TENURED FACULTY: 1976-2000 ASSUMING ALTERNATIVE PROMOTION RATES

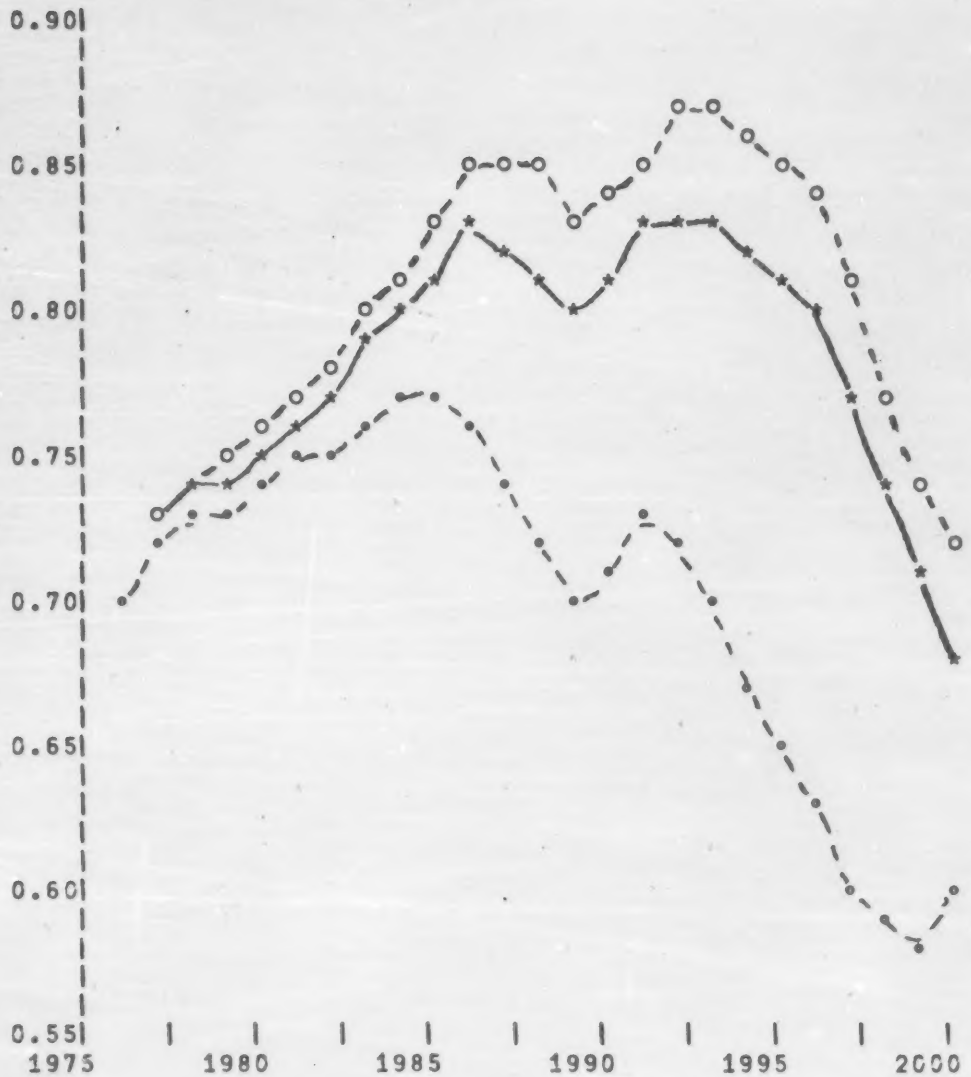


o - *PROJECTION ASSUMING HIGH PROMOTION RATES*
★ - *PROJECTION ASSUMING BASELINE PROMOTION RATES*
• - *PROJECTION ASSUMING LOW PROMOTION RATES*

THE UPPER THREE PLOTS ARE TENURED FACULTY, WHILE THE LOWER THREE PLOTS ARE THE NON-TENURED FACULTY

FIGURE 3-5

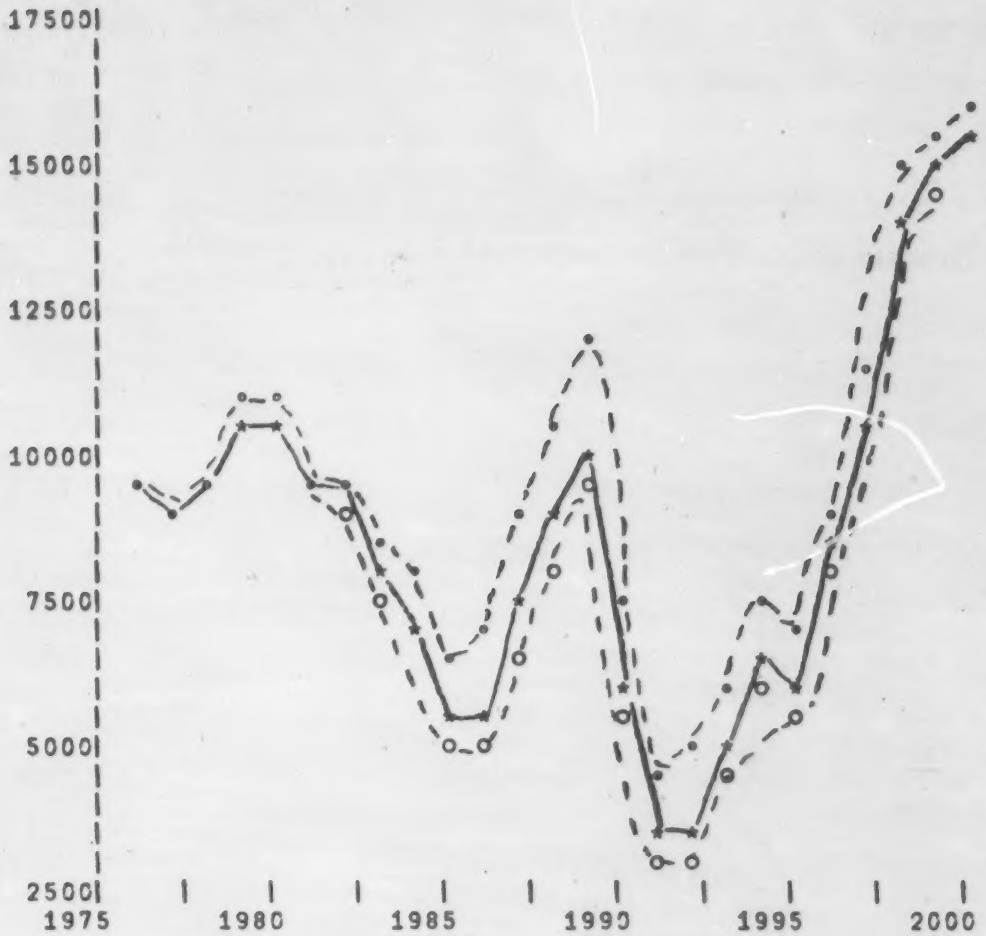
PROJECTIONS OF THE TENURE RATIO
ASSUMING ALTERNATIVE PROMOTION RATES



o - *PROJECTION ASSUMING HIGH PROMOTION RATES*
* - *PROJECTION ASSUMING BASELINE PROMOTION RATES*
• - *PROJECTION ASSUMING LOW PROMOTION RATES*

FIGURE 3-6

PROJECTIONS OF NEW DOCTORATES HIRES ASSUMING ALTERNATIVE PROMOTION RATES



o - *PROJECTION ASSUMING HIGH PROMOTION RATES*
★ - *PROJECTION ASSUMING BASELINE PROMOTION RATES*
• - *PROJECTION ASSUMING LOW PROMOTION RATES*

implying that the number of promotions does not differ much between scenarios. Since the promotion rates differ greatly, the size of the non-tenured pool must be differing greatly between scenarios. Table 3-7 shows this to be the case. Because the non-tenured faculty's quit rates are assumed to be much larger than the quit rates among tenured faculty, if the promotion rate falls then the attrition rate increases. Higher attrition rates result in increased hiring of new doctorates, hence increased numbers of non-tenured faculty. For example, by the early 1990s, hiring is 20% higher in the low promotion scenario than in the baseline scenario. As a result, although the promotion rate in 1990 under the low promotion scenario is half that projected under the baseline scenario, there are twice as many non-tenured faculty to promote that year. Total promotions to tenure are the same under both scenarios.

The tenure ratio, however, is quite sensitive to the promotion rates assumed. By the 1990s the tenure ratio is about 15% lower in the low promotion scenario than in the baseline. In 1993, the tenure ratio peaks at 0.87 under the high promotion scenario, but is only 0.7 under the low promotion scenario. This sensitivity appears puzzling considering that the rate of attrition of tenured faculty is robust to variations in the promotion probabilities (see Table 3-10), that total faculty demand is the same under the three scenarios, and that the number of promotions to tenure is "fairly" robust to changes in the promotion rate (see Table 3-7). The answer lies in noting that while the number of promotions is "fairly" robust, from 1985 to 1987 and 1992 to 1995 the number of promotions under the low promotion scenario is almost zero, since the promotion rate is assumed to be almost zero. The divergence in the tenure ratio between the different scenarios occurs primarily during these 7 years. If we had placed

TABLE 3-7
ALTERNATIVE PROJECTIONS OF PROMOTION TO TENURE

YEAR	*SCENARIO*	*NON-TENURED FACULTY*	*PROMOTION RATE*	*PROMOTIONS*
1980	*LOW PROMOTIONS*	52021	0.116	6032
	HIGH PROMOTIONS	47668	0.145	6910
1985	*LOW PROMOTIONS*	45326	0.031	1404
	HIGH PROMOTIONS	31504	0.148	4662
1990	*LOW PROMOTIONS*	56074	0.075	4200
	HIGH PROMOTIONS	29919	0.135	4035
1995	*LOW PROMOTIONS*	64076	0.006	385
	HIGH PROMOTIONS	26000	0.133	3458
2000	*LOW PROMOTIONS*	82998	0.151	12533
	HIGH PROMOTIONS	55820	0.128	7145

SOURCES: TABLE 3-12.

a much higher bound on our date effects-- 0.5, for example-- the large divergence in the evolution of the tenure ratio between the low and high promotion scenarios would be greatly attenuated.

Since a high tenure ratio appears to imply a lack of room for young faculty, it would be of interest to know what promotion rates would keep the tenure ratio constant. We are now in a position to approximate such a series. If we define: $T(t)$ = the number of tenured faculty at time t; $N(t)$ = the number of non-tenured faculty at t; $q(N;t)$ = the rate of attrition of non-tenured faculty at t; $q(T;t)$ = the rate of attrition of tenured faculty at t; $h(t)$ = new doctorate hires as a fraction of non-tenured faculty at t; Δ = the one-period difference operator; then we have the identity:

$$\Delta \ln N(t)/T(t) = h(t) - [q(N;t) - q(T;t)] - [1 + N(t)/T(t)]p(t).$$

We have already seen that $q(N;t)$ and $q(T;t)$ are robust to the evolution of the mean promotion rate, $p(t)$. In addition, table 3-12 can be used to show that $h(t)$ differs little among scenarios. As a result, the first three terms on the right-hand side of the equation above can be considered (time-dependent) constants, independent of $p(t)$. The tenure ratio remaining constant is equivalent to the right-hand side of the equation being identically zero. Setting $N(1975)/T(1975) = n^*$, we find that the promotion rates that keep the tenure ratio approximately constant satisfy the equation:

$$p^*(t) = [h(t) - q(N;t) + q(T;t)]/[1 + n^*] .$$

TABLE 3-8

Year	p*(t)	Baseline Promotion Rates	Percentage Difference
1976	0.135	0.193	30.5%
1980	0.133	0.135	1.5
1985	0.043	0.111	61.3
1990	0.068	0.117	42.0
1995	0.117	0.102	-14.7
2000	0.047	0.094	50.0

Source: Table 3-12 and author's calculations.

The sizable differences between the baseline and "counter-cyclical" promotion rates given in Table 3-8 suggest that almost the only way to keep the tenure ratio from increasing is to impose a "tenure freeze" after 1980. Since this does not seem a very reasonable policy, we will need to re-examine what "high" tenure ratios mean. It need not mean a "high" tenure ratio among total faculty, since four-year institutions have a substantial number of non-doctorate faculty who are also candidates for tenure. A high tenure ratio among doctorate faculty is consistent with even a declining tenure ratio among total faculty, as long as the fraction of non-doctorates with tenure declines sufficiently enough through attrition and lower promotion rates. Since in the coming period of academic contraction one would expect higher credentials to be demanded of both new hires and those given tenure, a rising tenure ratio among doctorate faculty need not be cause for such alarm.

Faculty hiring is more robust to the promotion rate than the tenure ratio, yet a low promotion scenario increases projected hiring by an average of 843 a year over the baseline projection. In no year, however, is hiring more than 2,000 above the baseline. This increased hiring, unfortunately, is somewhat of a mirage, resulting entirely from a higher turn-over among non-tenured faculty. In the low promotion scenario, we have merely succeeded in keeping a few more new doctorate graduates from the unemployment roles for four to six years before forcing them to find a permanent non-academic job. Any increase in long-run employment opportunities for young faculty must be due either to increased attrition of older faculty or increased demand by institutions for faculty. Either tenured faculty must be encouraged to retire or quit, or institutions must be encouraged to raise their demand for doctorates. Any other policies implicitly involve putting non-tenured faculty through a "revolving door." Faculty attrition is the focus of the next two sections.

TABLE 3-9

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROMOTION RATES

TOTAL FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	4	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	5	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	6	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
1980	4	0.069	0.198	0.368	0.549	0.701	0.836	0.929	0.987	1.000	43.6	0.031
	5	0.070	0.199	0.369	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.031
	6	0.071	0.200	0.369	0.549	0.699	0.835	0.929	0.987	1.000	43.6	0.032
1985	4	0.043	0.150	0.273	0.442	0.612	0.766	0.899	0.981	1.000	46.6	0.038
	5	0.046	0.153	0.275	0.443	0.612	0.766	0.899	0.980	1.000	46.6	0.040
	6	0.051	0.161	0.280	0.444	0.610	0.765	0.898	0.980	1.000	46.6	0.046
1990	4	0.050	0.137	0.242	0.366	0.527	0.699	0.853	0.971	1.000	49.2	0.035
	5	0.054	0.145	0.248	0.369	0.527	0.699	0.853	0.971	1.000	49.2	0.037
	6	0.066	0.170	0.267	0.378	0.528	0.698	0.851	0.971	1.000	49.1	0.043
1995	4	0.041	0.127	0.219	0.333	0.459	0.630	0.810	0.954	1.000	51.3	0.033
	5	0.044	0.135	0.230	0.339	0.461	0.631	0.810	0.954	1.000	51.3	0.033
	6	0.053	0.162	0.264	0.359	0.466	0.632	0.808	0.952	1.000	51.2	0.034
2000	4	0.100	0.241	0.344	0.443	0.544	0.657	0.808	0.950	1.000	47.8	0.035
	5	0.102	0.246	0.352	0.451	0.548	0.660	0.808	0.949	1.000	47.5	0.035
	6	0.106	0.262	0.381	0.482	0.566	0.669	0.810	0.948	1.000	46.0	0.034

NOTES:
1. *PROJECTION 4 ASSUMES HIGH PROMOTION RATES. PROJECTION 5 ASSUMES THE BASELINE PROMOTION RATES, WHILE PROJECTION 6 ASSUMES LOW PROMOTION RATES.*

TABLE 3-10

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROMOTION RATES

TENURED FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	4	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	5	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	6	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
1980	4	0.006	0.068	0.235	0.442	0.629	0.795	0.912	0.986	1.000	46.4	0.019
	5	0.006	0.065	0.231	0.438	0.626	0.793	0.911	0.986	1.000	46.5	0.018
	6	0.005	0.060	0.223	0.430	0.620	0.790	0.910	0.986	1.000	46.7	0.018
1985	4	0.004	0.058	0.170	0.354	0.549	0.727	0.882	0.978	1.000	48.7	0.023
	5	0.003	0.052	0.159	0.342	0.539	0.721	0.880	0.977	1.000	48.9	0.023
	6	0.002	0.036	0.131	0.312	0.514	0.705	0.872	0.976	1.000	49.6	0.023
1990	4	0.003	0.037	0.131	0.263	0.447	0.648	0.828	0.967	1.000	51.3	0.027
	5	0.003	0.032	0.117	0.245	0.430	0.635	0.822	0.965	1.000	51.7	0.026
	6	0.002	0.016	0.067	0.176	0.367	0.589	0.798	0.961	1.000	53.0	0.026
1995	4	0.002	0.039	0.115	0.233	0.375	0.571	0.780	0.947	1.000	53.3	0.032
	5	0.002	0.033	0.101	0.212	0.352	0.553	0.769	0.944	1.000	53.8	0.032
	6	0.000	0.008	0.039	0.109	0.237	0.460	0.716	0.930	1.000	55.8	0.031
2000	4	0.008	0.056	0.143	0.251	0.381	0.533	0.738	0.931	1.000	54.0	0.033
	5	0.006	0.046	0.127	0.232	0.359	0.513	0.725	0.927	1.000	54.6	0.033
	6	0.009	0.061	0.144	0.238	0.339	0.479	0.699	0.918	1.000	55.6	0.033

NOTES:

1. *PROJECTION 4 ASSUMES HIGH PROMOTION RATES. PROJECTION 5 ASSUMES THE BASELINE PROMOTION RATES, WHILE PROJECTION 6 ASSUMES LOW PROMOTION RATES.*

TABLE 3-11
PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE PROMOTION RATES

NON-TENURED FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	4	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	5	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	6	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
1980	4	0.282	0.636	0.816	0.910	0.942	0.973	0.985	0.992	1.000	32.8	0.073
	5	0.277	0.629	0.812	0.908	0.940	0.972	0.985	0.991	1.000	32.9	0.073
	6	0.267	0.616	0.804	0.903	0.936	0.971	0.985	0.991	1.000	33.1	0.074
1985	4	0.256	0.649	0.837	0.924	0.961	0.979	0.990	0.996	1.000	32.9	0.117
	5	0.244	0.631	0.826	0.917	0.955	0.977	0.989	0.996	1.000	33.1	0.120
	6	0.222	0.596	0.802	0.902	0.946	0.973	0.987	0.995	1.000	33.6	0.128
1990	4	0.311	0.694	0.863	0.945	0.973	0.989	0.994	0.998	1.000	32.2	0.084
	5	0.282	0.651	0.836	0.928	0.961	0.985	0.992	0.997	1.000	32.7	0.084
	6	0.226	0.558	0.772	0.887	0.934	0.974	0.987	0.996	1.000	34.1	0.085
1995	4	0.283	0.662	0.854	0.941	0.972	0.991	0.996	0.998	1.000	32.7	0.037
	5	0.235	0.594	0.808	0.911	0.953	0.982	0.992	0.997	1.000	33.6	0.038
	6	0.152	0.451	0.690	0.832	0.900	0.957	0.982	0.993	1.000	35.8	0.039
2000	4	0.353	0.746	0.892	0.966	0.988	0.996	0.998	1.000	1.000	31.6	0.039
	5	0.318	0.695	0.857	0.942	0.972	0.989	0.995	0.999	1.000	32.1	0.039
	6	0.254	0.567	0.739	0.854	0.911	0.956	0.979	0.993	1.000	33.7	0.036

NOTES:
1. *PROJECTION 4 ASSUMES HIGH PROMOTION RATES. PROJECTION 5 ASSUMES THE BASELINE PROMOTION RATES, WHILE PROJECTION 6 ASSUMES LOW PROMOTION RATES.*

TABLE 3-12

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE PROMOTION RATES

OTHER STATISTICS

		1976	1980	1985	1990	1995	2000
TENURE RATIO	4	0.687	0.770	0.845	0.849	0.860	0.732
	5	0.687	0.763	0.825	0.817	0.818	0.691
	6	0.687	0.749	0.777	0.717	0.654	0.603
PROMOTION RATE	4	0.193	0.145	0.148	0.135	0.133	0.128
	5	0.193	0.135	0.111	0.117	0.102	0.094
	6	0.193	0.116	0.031	0.075	0.006	0.151
TURNOVER RATE	4	0.049	0.051	0.025	0.027	0.031	0.074
	5	0.049	0.052	0.028	0.029	0.032	0.075
	6	0.049	0.053	0.033	0.037	0.037	0.077
TOTAL FACULTY	4	188561	207255	203258	198142	185729	209065
	5	188561	207255	203258	198142	185729	209065
	6	188561	207255	203258	198142	185729	209065

NOTES:

1. *PROJECTION 4 ASSUMES HIGH PROMOTION RATES. PROJECTION 5 ASSUMES THE BASELINE PROMOTION RATES, WHILE PROJECTION 6 ASSUMES LOW PROMOTION RATES.*
2. *THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.*

TABLE 3-13

PROJECTIONS OF THE TENURE RATIO ASSUMING ALTERNATIVE PROMOTION RATES

YEAR	HIGH PROMOTION	MEDIUM PROMOTION (BASELINE)	LOW PROMOTION
1976	0.0	0.703	0.0
1977	0.2	0.724	-0.4
1978	0.5	0.738	-0.9
1979	0.8	0.745	-1.4
1980	1.0	0.751	-1.9
1981	1.1	0.762	-2.1
1982	1.2	0.772	-2.4
1983	1.6	0.786	-3.3
1984	1.9	0.799	-4.3
1985	2.5	0.814	-5.9
1986	3.1	0.825	-7.9
1987	3.7	0.823	-9.7
1988	4.2	0.813	-11.5
1989	4.2	0.800	-12.5
1990	3.9	0.807	-12.4
1991	3.6	0.825	-11.6
1992	4.0	0.833	-13.7
1993	4.6	0.829	-15.5
1994	5.1	0.817	-17.5
1995	5.1	0.810	-19.6
1996	4.9	0.796	-20.4
1997	4.8	0.773	-21.8
1998	4.8	0.738	-20.7
1999	5.1	0.706	-17.8
2000	5.8	0.678	-12.2

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 3-14

PROJECTIONS OF NEW DOCTORATES HIRED ASSUMING ALTERNATIVE PROMOTION RATES

YEAR	HIGH PROMOTION	MEDIUM PROMOTION (BASELINE)	LOW PROMOTION
1976	-0.0	9327	0.0
1977	-0.1	9222	0.2
1978	-0.4	9633	0.6
1979	-0.6	10642	1.2
1980	-1.0	10698	1.8
1981	-1.4	9488	2.7
1982	-1.8	9294	3.7
1983	-3.2	7790	6.6
1984	-4.7	7197	10.2
1985	-8.5	5609	20.0
1986	-10.2	5661	26.3
1987	-8.8	7315	22.7
1988	-7.3	8852	20.0
1989	-5.7	10170	16.9
1990	-8.4	5817	26.1
1991	-11.7	3351	37.3
1992	-10.4	3542	35.5
1993	-7.0	5073	23.1
1994	-4.7	6473	16.2
1995	-3.9	5960	14.9
1996	-2.6	8319	10.8
1997	-2.0	10482	9.0
1998	-1.4	14153	6.2
1999	-1.4	14960	4.9
2000	-1.5	15709	3.0

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

4. Quit Rates

The reasons faculty leave academia are essentially three: death, retirement and "other reasons". The "other reasons" we will call quits, although they include leaves of absence and terminations as well as voluntary moves to non-academic jobs. Doctorate-trained men and women, particularly scientists and engineers, also move from non-academic employment into academic jobs; we will refer to this flow as experienced hires. Quits less experienced hires we will call net quits. If net quits in a given year are negative, we understand this to mean that the inflow exceeded the outflow. Incorporating experienced hires into quits allows us to equate "hiring" with the hiring of new doctorates, a number of more interest than total hiring. We define the age-specific net quit rate, q_{it}, to be the number of net quits during year t among faculty who recieved their doctorates i years ago divided by the number of faculty in year t who received their doctorates i years ago.

We will accept Freeman's contention (Freeman [1971]) that net quit rates respond rather predictably to changes in the relative compensation of academic and non-academic employment. Since the next two decades of projected faculty contraction suggests a fall in relative faculty salaries, our first assumption is that the years 1976 to 2000 will be a period of positive net quits. Our second assumption is that $q_{it} = a_i b_t$. This decomposition is similiar to that assumed previously for our promotion rates. We call a_i the "age effect," and b_t the "date effect". This is equivalent to assuming that at every date $q_{it}/q_{0t} = a_i$. Unfortunately, we cannot offer any theoretical support for this strong assumption. In the case of tenured faculty, whose quit rates can not be expected to change

that much, our assumption can be considered simply an approximation. However, in the case of non-tenured faculty, any shift in the proportion of "voluntary" quits (due to a change in career plans, for example) and "involuntary" quits (due to denial of tenure, for example) could be expected to shift the proportions q_{it}/q_{kt} over time. Such shifts are likely to occur, though, only until expectations of future job opportunities equilibrate to the new reality of lowered demand for faculty. However, in the new equilibrium situation there is no reason to expect the a_i to agree with those currently observed. Yet because we have no information on what the new age effects might look like, our "best estimate" is to use the current ones.

Our lack of theoretical basis for our assumptions is matched by a lack of data on which to estimate a_i and project b_t. Up to this point we have had a substantial amount of data to guide us in the construction of projections of our parameters. In the case of demand we had fairly robust estimates of enrollments; the link to faculty demand was the faculty-student ratio, with which we could experiment. Likewise with our promotion probabilities, past relationships to enrollments and new doctorates provided a basis for extrapolation. In contrast, Cartter provides us with the only information on relative quit rates by age; these were constructed from responses to two surveys of faculty conducted in 1963 and 1969.[6] In an appendix to this report, we show how we used Cartter's figures to estimate our age effects. Freeman has calculated past (aggregate) quit rates from N.S.F. data (Freeman [1971], p.178), giving us some idea of the magnitudes and the likely rates of change. However, we know of no studies of the determinants of quit rate changes.

Let $q_{it}(N)$ and $q_{it}(T)$ be the non-tenured and tenured quit rates, respectively; $q_{it}(N) = a_i(N)\, b_t(N)$ and $q_{it}(T) = a_i(T)\, b_t(T)$. The $a_i(N)$ and $a_i(T)$ have been normalized so that $b_t(N)$ and $b_t(T)$ correspond to the mean non-tenured quit rate and mean tenured quit rate, respectively, if the tenured and non-tenured age distributions in year t are the same as those that prevalied in 1975. Hence, in the same way we constructed a standardized promotion rate from the date effects of our promotion probabilities, the date effects of our quit rates represent "standardized" quit rates. Our third assumption is that $b_t(N)$ and $b_t(T)$ will increase during the years 1976 to 1986 and then decline to their 1975 levels, remaining constant after 1995. We view the period of increasing quits as one where faculty are re-thinking their career plans and institutions are readjusting their compensation and promotion policies in the wake of declining enrollment. After 1986, we see the academic labor market as returning to equilibrium. When the second larger contraction in enrollments occurs in the 1990's, it will not be a shock either to faculty or to colleges, and quit rates will not rise once more.

Our different projections of $b_t(N)$ and $b_t(T)$ differ, then, only in the level at which they peak in 1986. We have constructed six scenarios in order to study the robustness of our projections to these peak values. The assumptions of these scenarios are given below; note that scenario 2 and scenario 5 are the same, namely the "baseline" scenario. We assume that the mean quit rate of tenured faculty in 1975 is 0.005 or 0.5%, while the mean quit rate for non-tenured faculty is 2%.[7]

ALTERNATIVE PEAK QUIT RATES

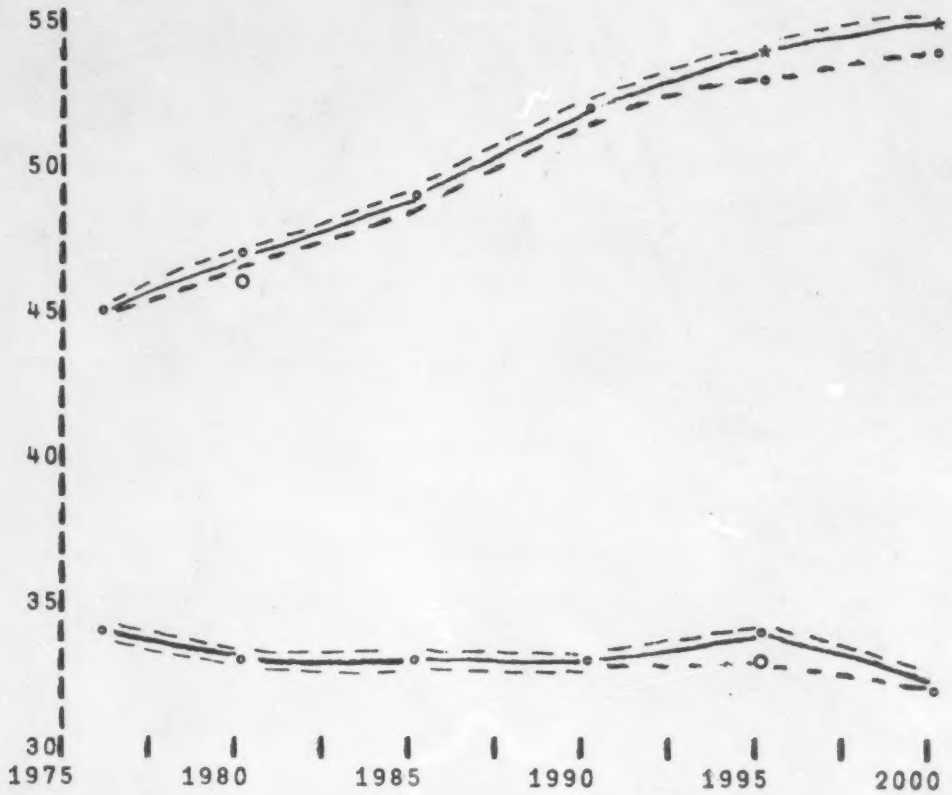
Scenario	$b_{1986}(T)$	$b_{1986}(N)$
1. "low tenured quit rates"	0.005	0.13
2. "medium tenured quit rates"	0.01	0.13
3. "high tenured quit rates"	0.02	0.13
4. "low non-tenured quit rates"	0.01	0.08
5. "medium non-tenured quit rates"	0.01	0.13
6. "high non-tenured quit rates"	0.01	0.18

Figures 4-1 through 4-6 summarize our findings, which are reported in detail in Tables 4-7 through 4-18 at the end of this section. The age distributions are very robust to both the tenured and non-tenured quit rates. This is not surprising since we have assumed in each scenario that the relative rate of attrition at each age is a constant. Only the level of attrition is varied over time and between scenarios. The size of new faculty varies between scenarios as a result of different replacement needs, yet apparently the change is not large enough to affect the over-all age distribution by very much. If hiring were artificially kept the same in the six scenarios we predict that the age distributions would not change at all.

The tenure ratio is sensitive to the tenured quit rate, but not to the non-tenured quit rate. The higher either quit rate rises to, the lower the tenure ratio over the period. Using the notation introduced in Section 2, we can account for both effects with the identity:

FIGURE 4-1

PROJECTIONS OF MEDIAN AGES OF TENURED AND NON-TENURED FACULTY: 1976-2000 ASSUMING ALTERNATIVE TENURED QUIT RATES

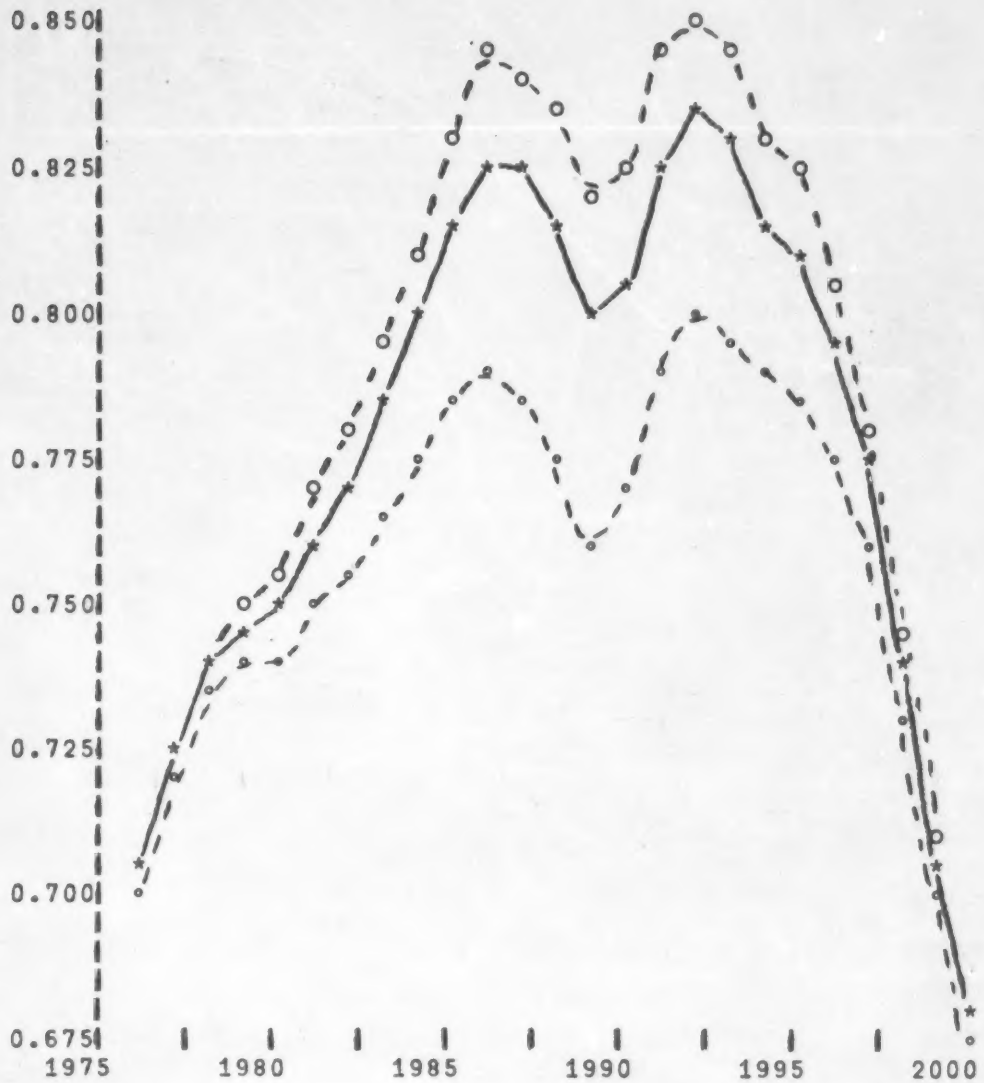


o - *PROJECTION ASSUMING LOW QUIT RATES*
* - *PROJECTION ASSUMING BASELINE QUIT RATES*
• - *PROJECTION ASSUMING HIGH QUIT RATES*

THE UPPER THREE PLOTS ARE TENURED FACULTY, WHILE THE LOWER THREE PLOTS ARE THE NON-TENURED FACULTY

FIGURE 4-2

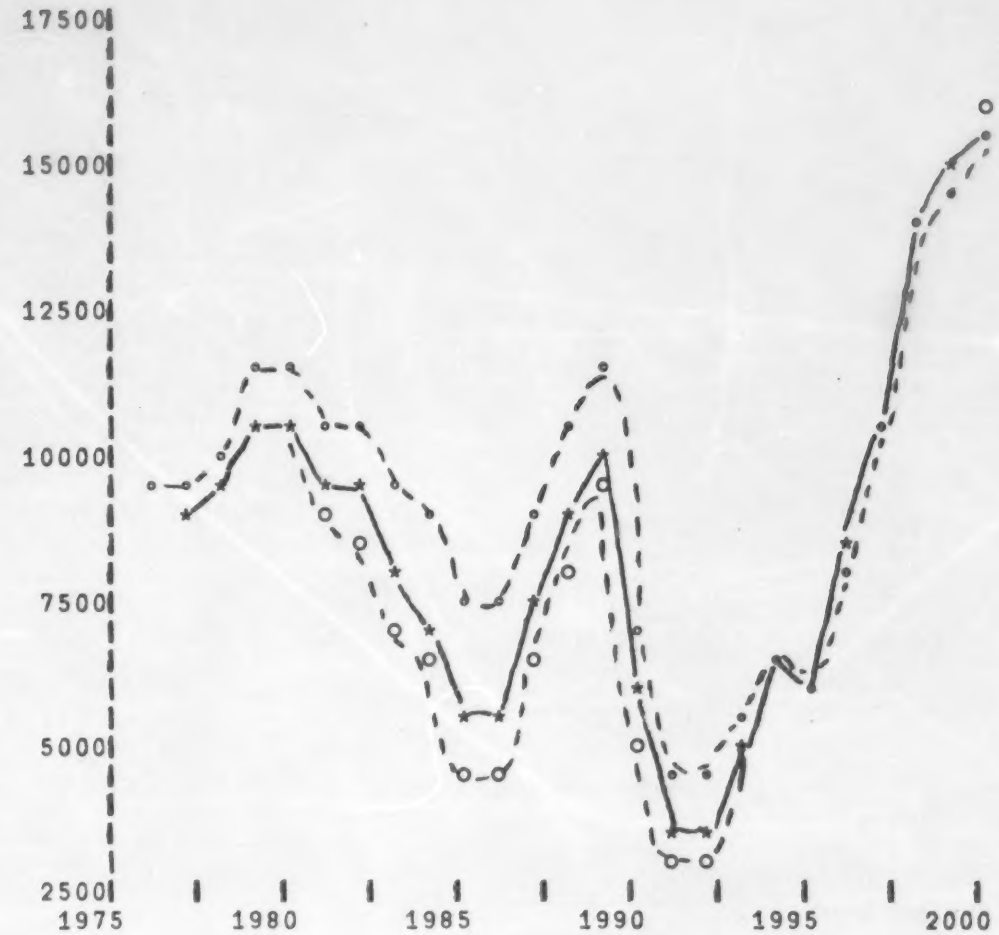
PROJECTIONS OF THE TENURE RATIO
ASSUMING ALTERNATIVE TENURED QUIT RATES



o - *PROJECTION ASSUMING LOW QUIT RATES*
* - *PROJECTION ASSUMING BASELINE QUIT RATES*
∘ - *PROJECTION ASSUMING HIGH QUIT RATES*

FIGURE 4-3

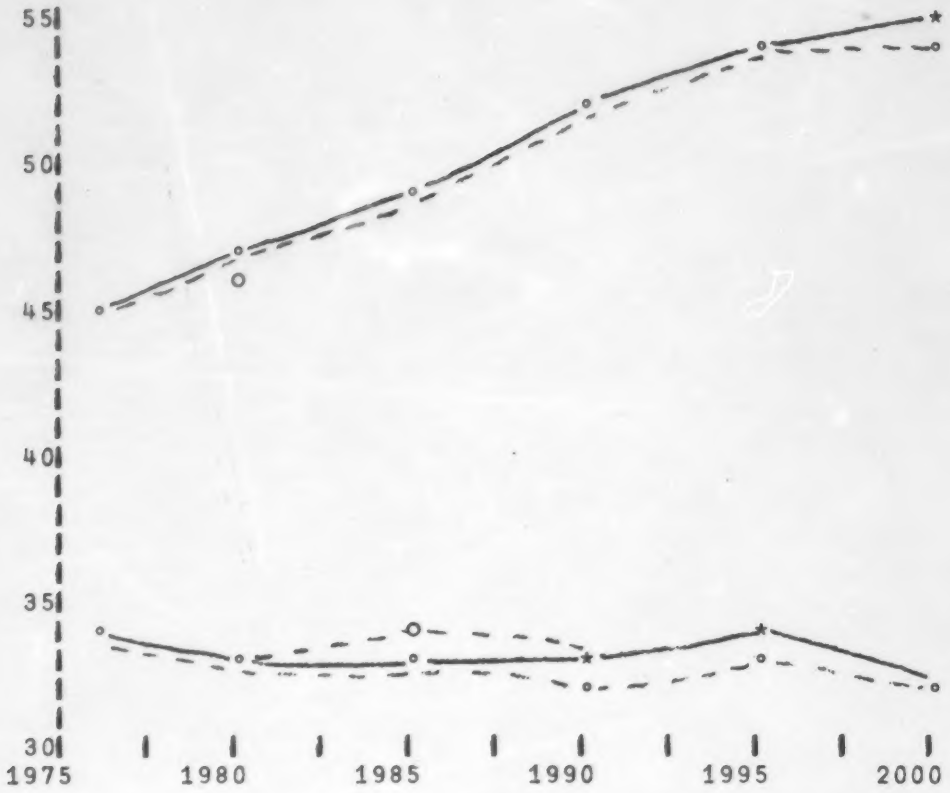
PROJECTIONS OF NEW DOCTORATES HIRES
ASSUMING ALTERNATIVE TENURED QUIT RATES



o - *PROJECTION ASSUMING LOW QUIT RATES*
* - *PROJECTION ASSUMING BASELINE QUIT RATES*
• - *PROJECTION ASSUMING HIGH QUIT RATES*

FIGURE 4-4

PROJECTIONS OF MEDIAN AGES OF TENURED AND NON-TENURED FACULTY: 1976-2000 ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

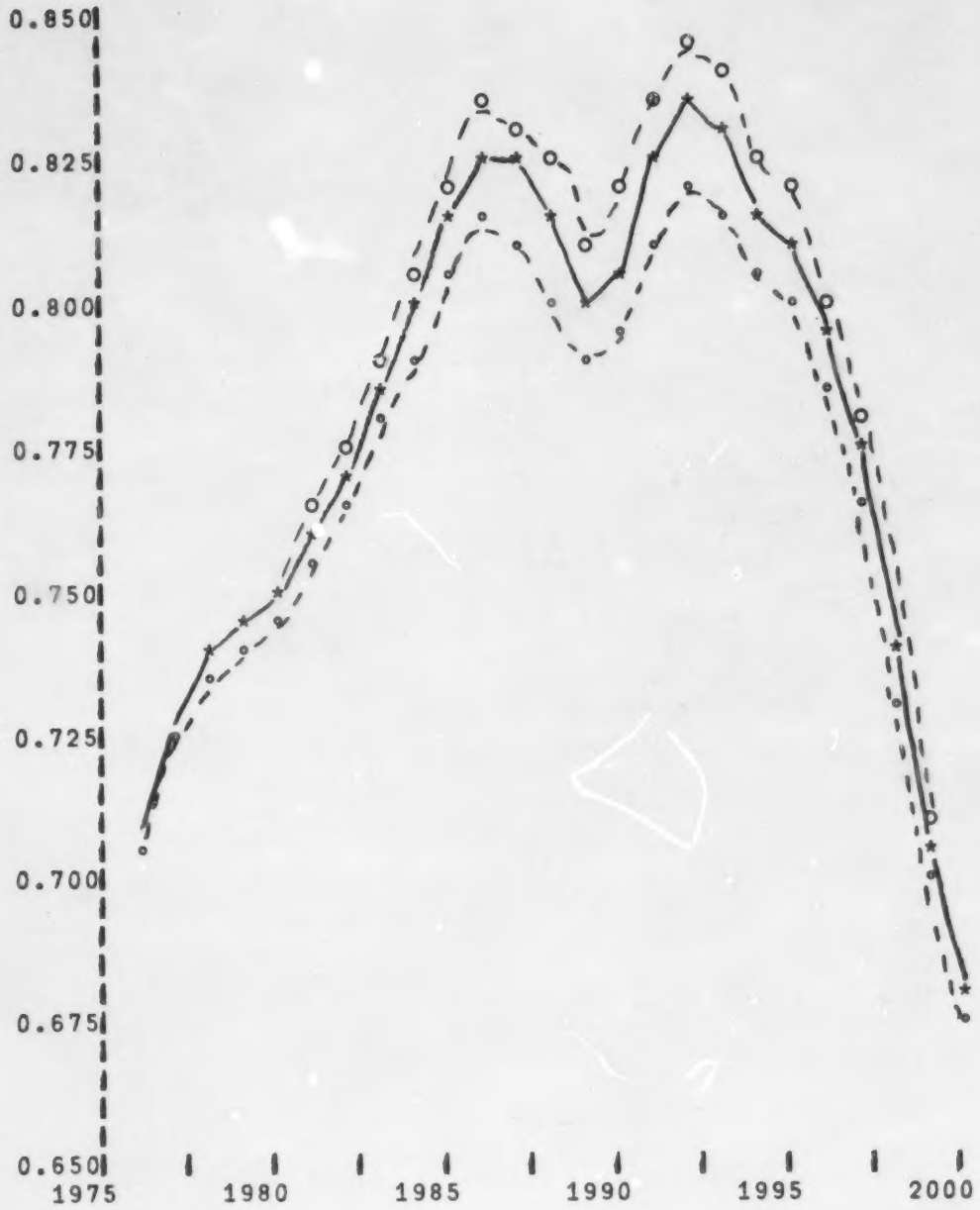


o - *PROJECTION ASSUMING LOW QUIT RATES*
* - *PROJECTION ASSUMING BASELINE QUIT RATES*
∘ - *PROJECTION ASSUMING HIGH QUIT RATES*

THE UPPER THREE PLOTS ARE TENURED FACULTY, WHILE THE LOWER THREE PLOTS ARE THE NON-TENURED FACULTY

FIGURE 4-5

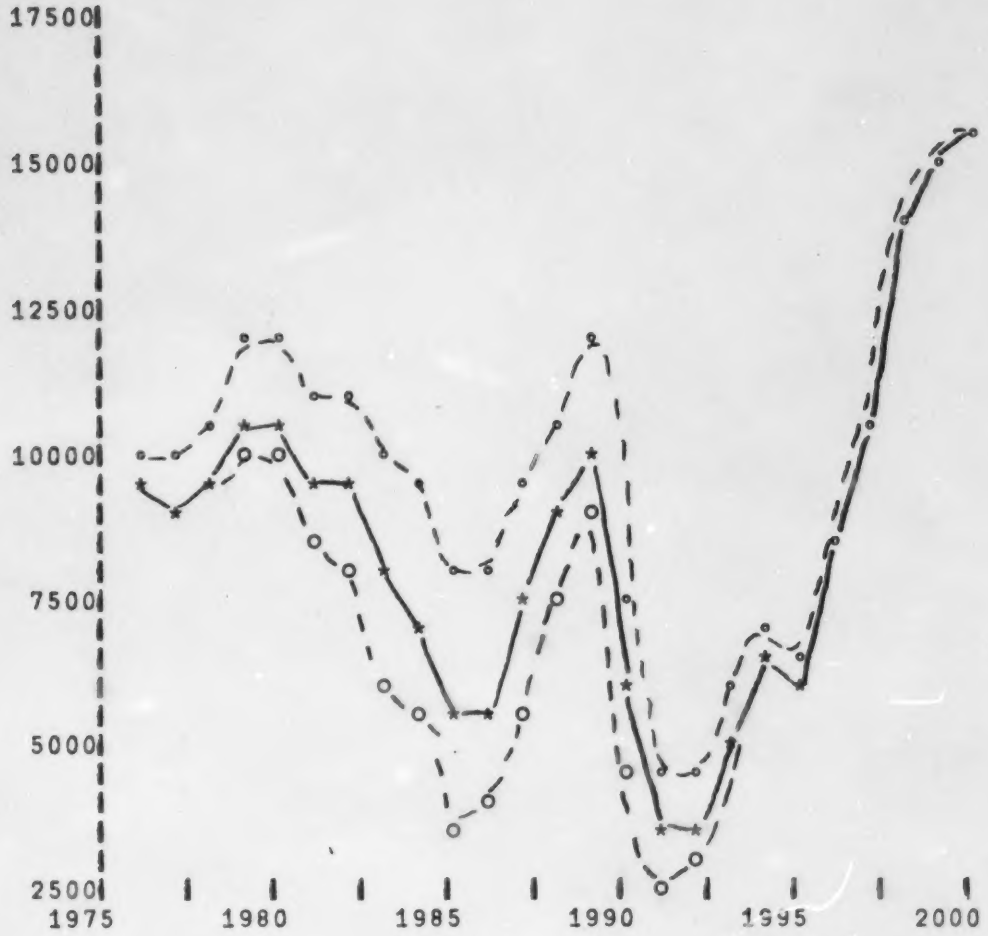
PROJECTIONS OF THE TENURE RATIO
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES



o - *PROJECTION ASSUMING LOW QUIT RATES*
★ - *PROJECTION ASSUMING BASELINE QUIT RATES*
• - *PROJECTION ASSUMING HIGH QUIT RATES*

FIGURE 4-6

PROJECTIONS OF NEW DOCTORATES HIRES
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES



o - *PROJECTION ASSUMING LOW QUIT RATES*
★ - *PROJECTION ASSUMING BASELINE QUIT RATES*
• - *PROJECTION ASSUMING HIGH QUIT RATES*

$$\Delta \ln \frac{T(t)}{T(t) + N(t)} = -q(T;t) + \frac{N(t)}{T(t)} p(t) - g(t),$$

where $g(t)$ = the percentage change in total doctorate faculty demand between the year t and t+1.

From this equation we see that the tenured quit rate affects the tenure ratio directly and negatively, while the non-tenured quit rate affects the tenure ratio only through the promotion rate. Since higher non-tenured quit rates prevent many faculty from advancing to the point when they are most likely to be promoted to tenure, the promotion rate is lower in the "high quit rate" scenario ; consequently, the tenure ratio is uniformly lower than in the baseline scenario. However, even the tenured quit rate is not an effective tool for reducing the tenure ratio. Note that even when the quit rate is assumed to quadruple, the tenure ratio still increases to almost 80% by 1986!

Both quit rates have a moderate impact on hiring, although hiring is projected to be so low during this period that even an increase of 20 or 30% over the baseline projections amounts to only at most 2000 more hires in any one year. The pattern of hiring in all of the projections is the same: an increase in the late 1970s, followed by a decline to 1986, a short rebound, and then another decline to 1995. Enrollment changes are still the dominant determinant of hiring levels. Over the 25 years we have projected, low tenured quit rates reduced hiring over the baseline projections by an average of only 415 people a year; high tenured quit rates increase hiring over the baseline by an average of only 775 people a year. A scenario with high non-tenured quit rates succeeds in increasing hiring by an average of 1,181 people a year over the baseline projections;

a scenario assuming low non-tenured quit rates decreases hiring over the baseline by only 767 people a year.

We have shown that increasing the quit rate of tenured faculty helps to cushion and even reverse some of the adverse consequences of declining faculty demand. However, academic institutions are not likely to gain these benefits without also risking a deterioration in the quality of their staff. Even the tenured faculty of a given school vary considerably in their teaching skills, creativity and productiveness. Although faculty do bargain separately with their departments over compensation, there are institutional constraints to salary differentials. These constraints exist partly to keep salaries from being used to undermine academic freedom of inquiry. However, these constraints may make it impossible for a college to reduce its real salaries without having its most versatile and prestigious faculty bid away from it by government agencies, industrial laboratories and consulting firms. Compounding this is the fact that a considerable part of faculty compensation takes the form of non-pecuniary benefits such as computer time, secretarial services, library services, positions for non-teaching visiting faculty, and sabbaticals. Many of these benefits have the characteristics of what economists call "public goods," i.e., their benefits and obligations cannot be parceled out to individuals, but of necessity extend to the entire community. Although some distinctions can be made between departments, cutbacks in any of the above will tend to affect everyone. If such things matter more to "high quality" faculty in choosing academic positions over non-academic positions, then academia can only increase its rate of attrition by accepting a

lower quality level among the faculty retained. It could be argued that those who leave are more "research oriented," and hence of little consequence in determining the quality of undergraduate teaching. This is a debatable contention. What is less debatable is that graduate training is likely to be seriously affected, particularly in the sciences. No university can be cavalier about unilaterally cutting or freezing faculty salaries or cutting back on academic perquisites in order to increase turnover and decelerate the aging of its faculty. It may end up worse off than if it simply waited for hiring to pick up on its own at the end of the century.

TABLE 4-7

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE TENURED QUIT RATES

TOTAL FACULTY

YEAR		*AGE DISTRIBUTION* ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	*MEDIAN AGE*	*ATTRITION RATE*
1976	7	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.024
	8	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	9	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.026
1980	7	0.068	0.195	0.366	0.547	0.699	0.835	0.929	0.987	1.000	43.7	0.029
	8	0.070	0.199	0.369	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.031
	9	0.074	0.206	0.375	0.554	0.703	0.837	0.929	0.987	1.000	43.5	0.036
1985	7	0.040	0.141	0.263	0.433	0.606	0.763	0.898	0.980	1.000	46.8	0.035
	8	0.046	0.153	0.275	0.443	0.612	0.766	0.899	0.980	1.000	46.6	0.040
	9	0.057	0.177	0.301	0.462	0.624	0.772	0.901	0.981	1.000	46.1	0.050
1990	7	0.049	0.130	0.228	0.350	0.513	0.691	0.849	0.971	1.000	49.6	0.034
	8	0.054	0.145	0.248	0.369	0.527	0.699	0.853	0.971	1.000	49.2	0.037
	9	0.064	0.175	0.288	0.407	0.554	0.715	0.859	0.972	1.000	48.2	0.042
					212	0.318	0.441	0.618	0.804	0.953	1.000	51.8	0.033
	8	0.044	0.135	0.230	0.339	0.461	0.631	0.810	0.954	1.000	51.3	0.033
	9	0.046	0.150	0.263	0.381	0.498	0.656	0.822	0.956	1.000	50.1	0.033
		0.103	0.247	0.348	0.439	0.533	0.646	0.801	0.947	1.000	48.3	0.035
	8	0.102	0.246	0.352	0.451	0.548	0.660	0.808	0.949	1.000	47.5	0.035
	9	0.100	0.243	0.359	0.472	0.575	0.684	0.822	0.952	1.000	46.3	0.034

NOTES:
1. *PROJECTION 7 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 8 ASSUMES THE MEAN QUIT RATES RISES TO .01 AND THEN DECLINES. PROJECTION 9 ASSUMES THE MEAN QUIT RATES RISES TO .02 AND THEN DECLINES TO ITS ORIGINAL VALUE OF .005.*

TABLE 4-8

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE TENURED QUIT RATES

TENURED FACULTY

YEAR		*AGE DISTRIBUTION* ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	*MEDIAN AGE*	*ATTRITION RATE*
1976	7	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	8	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	9	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.022
1980	7	0.005	0.065	0.231	0.439	0.626	0.794	0.912	0.986	1.000	46.5	0.016
	8	0.006	0.065	0.231	0.438	0.626	0.793	0.911	0.986	1.000	46.5	0.018
	9	0.006	0.065	0.231	0.437	0.624	0.792	0.911	0.986	1.000	46.5	0.023
1985	7	0.003	0.050	0.157	0.342	0.540	0.722	0.880	0.977	1.000	48.9	0.019
	8	0.003	0.052	0.159	0.342	0.539	0.721	0.880	0.977	1.000	48.9	0.023
	9	0.004	0.056	0.163	0.343	0.538	0.719	0.878	0.977	1.000	49.0	0.031
1990	7	0.003	0.028	0.109	0.237	0.425	0.634	0.821	0.966	1.000	51.8	0.025
	8	0.003	0.032	0.117	0.245	0.430	0.635	0.822	0.965	1.000	51.7	0.026
	9	0.004	0.041	0.133	0.260	0.439	0.639	0.822	0.965	1.000	51.5	0.030
1995	7	0.001	0.029	0.089	0.196	0.336	0.543	0.765	0.944	1.000	54.1	0.032
	8	0.002	0.033	0.101	0.212	0.352	0.553	0.769	0.944	1.000	53.8	0.032
	9	0.002	0.040	0.123	0.244	0.381	0.572	0.777	0.945	1.000	53.2	0.032
2000	7	0.006	0.045	0.120	0.216	0.338	0.494	0.714	0.925	1.000	55.2	0.033
	8	0.006	0.046	0.127	0.232	0.359	0.513	0.725	0.927	1.000	54.6	0.033
	9	0.006	0.047	0.140	0.264	0.399	0.548	0.745	0.932	1.000	53.5	0.031

NOTES:

1. *PROJECTION 7 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 8 ASSUMES THE MEAN QUIT RATES RISES TO .01 AND THEN DECLINES. PROJECTION 9 ASSUMES THE MEAN QUIT RATES RISES TO .02 AND THEN DECLINES TO ITS ORIGINAL VALUE OF .005.*

TABLE 4-9

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE TENURED QUIT RATES

NON-TENURED FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	7	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	8	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	9	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
1980	7	0.273	0.625	0.810	0.906	0.939	0.971	0.985	0.991	1.000	33.0	0.073
	8	0.277	0.629	0.812	0.908	0.940	0.972	0.985	0.991	1.000	32.9	0.073
	9	0.283	0.636	0.817	0.911	0.942	0.973	0.986	0.992	1.000	32.8	0.075
1985	7	0.231	0.618	0.817	0.911	0.952	0.975	0.988	0.995	1.000	33.3	0.118
	8	0.244	0.631	0.826	0.917	0.955	0.977	0.989	0.996	1.000	33.1	0.120
	9	0.263	0.653	0.839	0.926	0.961	0.980	0.990	0.996	1.000	32.8	0.124
1990	7	0.283	0.646	0.830	0.924	0.958	0.983	0.991	0.997	1.000	32.8	0.083
	8	0.282	0.651	0.836	0.928	0.961	0.985	0.992	0.997	1.000	32.7	0.084
	9	0.280	0.658	0.844	0.933	0.966	0.987	0.993	0.998	1.000	32.7	0.085
1995	7	0.244	0.603	0.811	0.912	0.953	0.981	0.992	0.996	1.000	33.5	0.038
	8	0.235	0.594	0.808	0.911	0.953	0.982	0.992	0.997	1.000	33.6	0.038
	9	0.219	0.580	0.804	0.910	0.952	0.983	0.993	0.997	1.000	33.9	0.038
2000	7	0.323	0.703	0.862	0.945	0.974	0.990	0.996	0.999	1.000	32.0	0.039
	8	0.318	0.695	0.857	0.942	0.972	0.989	0.995	0.999	1.000	32.1	0.039
	9	0.310	0.679	0.845	0.935	0.968	0.988	0.995	0.999	1.000	32.3	0.039

NOTES:
1. *PROJECTION 7 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 8 ASSUMES THE MEAN QUIT RATES RISES TO .01 AND THEN DECLINES. PROJECTION 9 ASSUMES THE MEAN QUIT RATES RISES TO .02 AND THEN DECLINES TO ITS ORIGINAL VALUE OF .005.*

TABLE 4-10

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE TENURED QUIT RATES

OTHER STATISTICS

		1976	1980	1985	1990	1995	2000
TENURE RATIO	7	0.687	0.768	0.840	0.835	0.830	0.694
	8	0.687	0.763	0.825	0.817	0.818	0.691
	9	0.687	0.753	0.796	0.782	0.795	0.690
PROMOTION RATE	7	0.193	0.136	0.115	0.117	0.099	0.093
	8	0.193	0.135	0.111	0.117	0.102	0.094
	9	0.193	0.133	0.106	0.119	0.106	0.096
TURNOVER RATE	7	0.049	0.050	0.023	0.026	0.032	0.076
	8	0.049	0.052	0.028	0.029	0.032	0.075
	9	0.050	0.056	0.037	0.035	0.032	0.073
TOTAL FACULTY	7	188561	207255	203258	198142	185729	209065
	8	188561	207255	203258	198142	185729	209065
	9	188561	207255	203258	198142	185729	209065

NOTES:

1. *PROJECTION 7 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 8 ASSUMES THE MEAN QUIT RATES RISES TO .01 AND THEN DECLINES. PROJECTION 9 ASSUMES THE MEAN QUIT RATES RISES TO .02 AND THEN DECLINES TO ITS ORIGINAL VALUE OF .005.*
2. *THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.*

TABLE 4-11

PROJECTIONS OF THE TENURE RATIO ASSUMING ALTERNATIVE TENURED QUIT RATES

YEAR	LOW QUIT RATES	MEDIUM QUIT RATES (BASELINE)	HIGH QUIT RATES
1976	0.1	0.703	-0.1
1977	0.2	0.724	-0.3
1978	0.3	0.738	-0.6
1979	0.5	0.745	-0.9
1980	0.7	0.751	-1.3
1981	0.9	0.762	-1.8
1982	1.1	0.772	-2.2
1983	1.4	0.786	-2.7
1984	1.6	0.799	-3.2
1985	1.9	0.814	-3.7
1986	2.2	0.825	-4.2
1987	2.4	0.823	-4.6
1988	2.5	0.813	-4.9
1989	2.5	0.800	-4.8
1990	2.4	0.807	-4.6
1991	2.2	0.825	-4.2
1992	2.1	0.833	-4.0
1993	2.0	0.829	-3.8
1994	1.8	0.817	-3.5
1995	1.5	0.810	-3.0
1996	1.2	0.796	-2.3
1997	1.0	0.773	-1.7
1998	0.7	0.738	-1.2
1999	0.5	0.706	-0.7
2000	0.3	0.678	-0.2

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 4-12

PROJECTIONS OF NEW DOCTORATES HIRED ASSUMING ALTERNATIVE TENURED QUIT RATES

YEAR	LOW QUIT RATES	MEDIUM QUIT RATES (BASELINE)	HIGH QUIT RATES
1976	-0.8	9327	1.5
1977	-1.7	9222	3.3
1978	-2.5	9633	5.0
1979	-3.1	10642	6.2
1980	-4.1	10698	8.0
1981	-5.7	9488	11.3
1982	-7.1	9294	13.9
1983	-10.0	7790	19.5
1984	-12.6	7197	24.4
1985	-18.4	5609	35.5
1986	-18.7	5661	35.9
1987	-13.3	7315	25.4
1988	-9.7	8852	18.7
1989	-7.3	10170	14.0
1990	-10.4	5817	20.3
1991	-14.3	3351	28.0
1992	-10.1	3542	20.0
1993	-4.7	5073	9.5
1994	-2.0	6473	4.0
1995	-0.3	5960	-0.8
1996	0.1	8319	-1.9
1997	0.3	10482	-2.0
1998	0.4	14153	-1.8
1999	0.6	14960	-2.0
2000	0.7	15709	-2.2

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 4-13

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

TOTAL FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	10	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.026
	11	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	12	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.028
		0.067	0.196	0.368	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.027
	11	0.070	0.199	0.369	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.031
	12	0.075	0.206	0.373	0.552	0.702	0.836	0.929	0.987	1.000	43.5	0.038
1985	10	0.036	0.141	0.269	0.439	0.610	0.765	0.898	0.980	1.000	46.7	0.032
	11	0.046	0.153	0.275	0.443	0.612	0.766	0.899	0.980	1.000	46.6	0.040
	12	0.056	0.168	0.286	0.449	0.616	0.768	0.899	0.981	1.000	46.4	0.050
1990	10	0.047	0.128	0.233	0.360	0.521	0.697	0.852	0.971	1.000	49.4	0.032
	11	0.054	0.145	0.248	0.369	0.527	0.699	0.853	0.971	1.000	49.2	0.037
	12	0.063	0.164	0.266	0.382	0.534	0.702	0.854	0.971	1.000	48.9	0.044
1995	10	0.042	0.125	0.211	0.324	0.452	0.626	0.808	0.953	1.000	51.5	0.034
	11	0.044	0.135	0.230	0.339	0.461	0.631	0.810	0.954	1.000	51.3	0.033
	12	0.049	0.149	0.250	0.358	0.474	0.637	0.812	0.954	1.000	50.9	0.036
2000	10	0.102	0.245	0.345	0.437	0.536	0.652	0.805	0.949	1.000	48.3	0.035
	11	0.102	0.246	0.352	0.451	0.548	0.660	0.808	0.949	1.000	47.5	0.035
	12	0.102	0.250	0.363	0.467	0.562	0.669	0.812	0.950	1.000	46.6	0.035

NOTES;
1. *PROJECTION 10 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 11 ASSUMES THE MEAN QUIT RATE RISES TO 0.13 AND THEN DECLINES. PROJECTION 12 ASSUMES THE MEAN QUIT RATE RISES TO 0.18 AND THEN DECLINES TO ITS ORIGINAL VALUE OF 0.04.*

TABLE 4-14

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

TENURED FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	10	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	11	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	12	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
1980	10	0.006	0.066	0.232	0.439	0.626	0.794	0.912	0.986	1.000	46.5	0.018
	11	0.006	0.065	0.231	0.438	0.626	0.793	0.911	0.986	1.000	46.5	0.018
	12	0.006	0.065	0.230	0.436	0.624	0.793	0.911	0.986	1.000	46.5	0.018
1985	10	0.003	0.052	0.161	0.345	0.542	0.723	0.881	0.977	1.000	48.9	0.023
	11	0.003	0.052	0.159	0.342	0.539	0.721	0.880	0.977	1.000	48.9	0.023
	12	0.004	0.054	0.159	0.340	0.536	0.719	0.878	0.977	1.000	49.0	0.023
1990	10	0.003	0.028	0.114	0.246	0.432	0.638	0.823	0.966	1.000	51.6	0.027
	11	0.003	0.032	0.117	0.245	0.430	0.635	0.822	0.965	1.000	51.7	0.026
	12	0.004	0.036	0.122	0.246	0.428	0.633	0.820	0.965	1.000	51.8	0.026
1995	10	0.001	0.029	0.090	0.203	0.348	0.552	0.770	0.945	1.000	53.8	0.032
	11	0.002	0.033	0.101	0.212	0.352	0.553	0.769	0.944	1.000	53.8	0.032
	12	0.002	0.037	0.111	0.222	0.357	0.554	0.769	0.944	1.000	53.7	0.032
2000	10	0.006	0.044	0.119	0.214	0.344	0.505	0.721	0.927	1.000	54.9	0.033
	11	0.006	0.046	0.127	0.232	0.359	0.513	0.725	0.927	1.000	54.6	0.033
	12	0.006	0.049	0.139	0.251	0.376	0.523	0.729	0.927	1.000	54.3	0.033

NOTES:

1. *PROJECTION 10 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 11 ASSUMES THE MEAN QUIT RATE RISES TO 0.13 AND THEN DECLINES. PROJECTION 12 ASSUMES THE MEAN QUIT RATE RISES TO 0.18 AND THEN DECLINES TO ITS ORIGINAL VALUE OF 0.04.*

TABLE 4-15

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

NON-TENURED FACULTY

YEAR		*AGE DISTRIBUTION* ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	*MEDIAN AGE*	*ATTRITION RATE*
1976	10	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.037
	11	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	12	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.046
	0	0.266	0.619	0.807	0.904	0.938	0.971	0.985	0.991	1.000	33.1	0.055
	11	0.277	0.629	0.812	0.908	0.940	0.972	0.985	0.991	1.000	32.9	0.073
	12	0.296	0.651	0.825	0.916	0.946	0.975	0.987	0.992	1.000	32.6	0.102
1985	10	0.199	0.582	0.798	0.898	0.944	0.972	0.987	0.995	1.000	33.8	0.073
	11	0.244	0.631	0.826	0.917	0.955	0.977	0.989	0.996	1.000	33.1	0.120
	12	0.286	0.678	0.854	0.936	0.967	0.983	0.992	0.997	1.000	32.5	0.170
1990	10	0.257	0.601	0.797	0.903	0.944	0.977	0.988	0.996	1.000	33.4	0.059
	11	0.282	0.651	0.836	0.928	0.961	0.985	0.992	0.997	1.000	32.7	0.084
	12	0.309	0.694	0.866	0.947	0.975	0.991	0.995	0.998	1.000	32.2	0.117
1995	10	0.235	0.579	0.783	0.891	0.939	0.973	0.988	0.995	1.000	33.8	0.041
	11	0.235	0.594	0.808	0.911	0.953	0.982	0.992	0.997	1.000	33.6	0.038
	12	0.247	0.624	0.836	0.931	0.966	0.990	0.996	0.998	1.000	33.3	0.051
2000	10	0.320	0.697	0.855	0.938	0.968	0.986	0.993	0.998	1.000	32.1	0.039
	11	0.318	0.695	0.857	0.942	0.972	0.989	0.995	0.999	1.000	32.1	0.039
	12	0.315	0.694	0.861	0.947	0.975	0.992	0.997	0.999	1.000	32.2	0.039

NOTES:

1. *PROJECTION 10 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 11 ASSUMES THE MEAN QUIT RATE RISES TO 0.13 AND THEN DECLINES. PROJECTION 12 ASSUMES THE MEAN QUIT RATE RISES TO 0.18 AND THEN DECLINES TO ITS ORIGINAL VALUE OF 0.04.*

TABLE 4-16

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

OTHER STATISTICS

		1976	1980	1985	1990	1995	2000
TENURE RATIO	10	0.687	0.764	0.831	0.826	0.824	0.693
	11	0.687	0.763	0.825	0.817	0.818	0.691
	12	0.687	0.760	0.816	0.806	0.809	0.689
PROMOTION RATE	10	0.193	0.139	0.124	0.123	0.100	0.093
	11	0.193	0.135	0.111	0.117	0.102	0.094
	12	0.193	0.128	0.100	0.110	0.100	0.095
TURNOVER RATE	10	0.051	0.047	0.018	0.024	0.033	0.075
	11	0.049	0.052	0.028	0.029	0.032	0.075
	12	0.053	0.059	0.039	0.038	0.035	0.075
TOTAL FACULTY	10	188561	207255	203258	198142	185729	209065
	11	188561	207255	203258	198142	185729	209065
	12	188561	207255	203258	198142	185729	209065

NOTES:

1. *PROJECTION 10 ASSUMES CONSTANT AGE-SPECIFIC QUIT RATES. PROJECTION 11 ASSUMES THE MEAN QUIT RATE RISES TO 0.13 AND THEN DECLINES. PROJECTION 12 ASSUMES THE MEAN QUIT RATE RISES TO 0.18 AND THEN DECLINES TO ITS ORIGINAL VALUE OF 0.04.*
2. *THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.*

TABLE 4-17

PROJECTIONS OF THE TENURE RATIO ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

YEAR	LOW QUIT RATES	MEDIUM QUIT RATES (BASELINE)	HIGH QUIT RATES
1976	0.0	0.703	-0.0
1977	0.0	0.724	-0.1
1978	0.0	0.738	-0.2
1979	0.0	0.745	-0.4
1980	0.1	0.751	-0.5
1981	0.2	0.762	-0.7
1982	0.4	0.772	-0.8
1983	0.5	0.786	-1.0
1984	0.7	0.799	-1.1
1985	0.9	0.814	-1.2
1986	1.0	0.825	-1.3
1987	1.1	0.823	-1.4
1988	1.2	0.813	-1.5
1989	1.3	0.800	-1.6
1990	1.3	0.807	-1.6
1991	1.3	0.825	-1.6
1992	1.2	0.833	-1.5
1993	1.2	0.829	-1.5
1994	1.1	0.817	-1.5
1995	1.0	0.810	-1.4
1996	0.8	0.796	-1.2
1997	0.6	0.773	-1.1
1998	0.5	0.738	-0.9
1999	0.4	0.706	-0.7
2000	0.3	0.678	-0.5

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 4-18

PROJECTIONS OF NEW DOCTORATES HIRED
ASSUMING ALTERNATIVE NON-TENURED QUIT RATES

YEAR	LOW QUIT RATES	MEDIUM QUIT RATES (BASELINE)	HIGH QUIT RATES
1976	-2.2	9327	7.6
1977	-1.0	9222	9.5
1978	-3.8	9633	11.0
1979	-6.0	10642	11.8
1980	-8.8	10698	14.0
1981	-13.0	9488	18.3
1982	-15.9	9294	20.7
1983	-22.1	7790	27.2
1984	-26.3	7197	31.1
1985	-36.4	5609	42.0
1986	-33.2	5661	39.0
1987	-21.7	7315	26.8
1988	-15.9	8852	20.5
1989	-12.4	10170	16.8
1990	-19.0	5817	27.3
1991	-24.1	3351	39.7
1992	-15.1	3542	29.6
1993	-6.3	5073	16.4
1994	-1.9	6473	10.4
1995	-1.3	5960	8.8
1996	-0.3	8319	0.5
1997	-0.1	10482	0.3
1998	0.0	14153	0.1
1999	0.0	14960	-0.0
2000	0.1	15709	-0.1

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

5. Retirement Rates

Since increasing the quit rate of its tenured faculty is not a policy any school would pursue unilaterally, and increasing the quit rate of non-tenured faculty has little effect on the tenure ratio or the age distribution, the retirement rate becomes the only useful policy variable by which an institution can increase its attrition rate without risking a deterioration in the quality of its staff. Faculty near retirement age must seem particularly expendable to college administrators. Whatever prestige the older faculty have given to their college will not be taken away the moment they leave. Furthermore, evidence exists that the more tangible evidences of academic "productivity" decline with age (Tuckman and Leakey [1975]). Interestingly, research during the last decade suggests that faculty are retiring earlier (King [1970], Patton [1973]). The source of this trend is not known, however. Faculty could be taking advantage of more generous pensions and social security benefits and retiring earlier voluntarily, or more schools could be lowering their age of mandatory retirement and reducing the number of faculty allowed to stay past the "normal age" of retirement.

Unfortunately, such knowledge has become crucial for projecting likely retirement rates in the near future. During the previous year, a number of state and federal laws have changed the legal framework within which the trend toward earlier retirement was occuring by eliminating mandatory retirement based solely on age. In the vanguard of the movement toward eliminating mandatory retirement, in 1977 California passed a law (A.B. 568) barring mandatory retirement of any

state employee unless lack of competency can be proved; the only exceptions are police and firemen. In particular, the law provides that all state college and university faculty can remain active as long as they pass "uniform tests of competency." There is no longer any age of mandatory retirement. Other states are currently contemplating similar laws. The most far-reaching success of this political movement is the passage of amendments to the federal Age Discrimination in Employment Act of 1967 (PL 95-256). These amendments prohibit discrimination in promotion and retirement because of age to workers under the age of 70. The only class of employees exempted from the provisions of forced retirement are top management personnel and tenured faculty. Faculty, however, will come under the scope of the law after July 1, 1982.

Our first concern in this section is to project the short-run and long-run impacts on hiring, tenure and the age structure of faculty resulting from the legislative prohibition of mandatory retirement before the age of 70. Although the California law goes much further than this in barring all mandatory retirement of publicly-employed faculty (which is also a desire of Rep. Claude Pepper, the author of the federal bill), we will not attempt to determine the impact on academia of this more extreme measure. The data on the number of faculty over the age of 70 is much too poor in quality for us to have confidence in projections that assumed such a scenario. Should better data become available, we believe that the methodology developed here allows for a straightforward extension to this more extreme case. We will assume in each of our projections that all faculty retire, voluntary or not, by age 70.

Since retirement decisions at present are constrained by mandatory retirement provisions, we do not have reliable information as to what faculty would do when the constraint is removed. At first, it would seem that, at each age, retirement rates could only fall, since faculty are not restricted from retiring early. However, such a conclusion implicitly assumes that institutions do not introduce incentives for earlier voluntary retirement. Clearly, though, there are two extremes: (1) the age-specific retirement rates don't change, or (2) after the law takes effect, all retirement occurs at the age of 70. We will call the first possibility a no change response (NCR). An NCR could result from institutions adjusting their pension plans and pay scales so as to encourage faculty to retire at the old normal age. An NCR does not mean necessarily that nothing changes, only that retirement rates do not change. One of the purposes of this section is to determine whether it makes sense for academia to try to achieve an NCR. At the other extreme, if all faculty would prefer to stay on as long as possible, and all institutions decided to establish 70 as the new age of mandatory retirement, then after the law takes effect, all retirement would occur at age 70 only. We will call this an extreme response (XR). A "middle ground" between these two is to suppose that exactly half of those retiring at any age would opt to stay on at least one more year if given this option. For example, if currently 20% of faculty 65 years old retire at 65 (involuntarily or voluntarily), then a mild response would result in a fall in the fraction retiring to 10%. This mild response is our baseline assumption. Since academic institutions are given four years

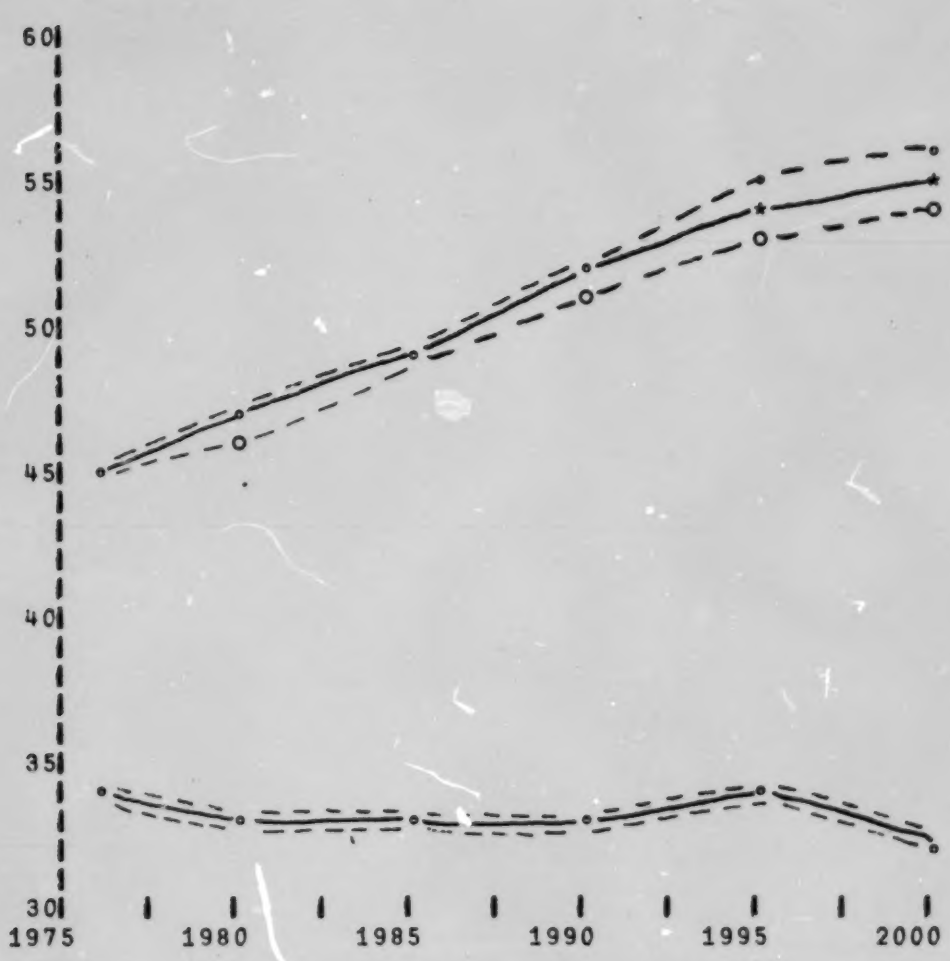
before having to comply with the law, we have assumed in our projections that the adjustment from the current rates to the new ones is smooth. In each scenario the GK-rates constructed in the appendix of this report are assumed to hold through 1978, while the new rates (which depend on the scenario) are assumed to hold after 1982.

Our projections are displayed in Tables 5-8 through 5-13, located at the end of this section. Figures 5-1, 5-2 and 5-3 summarize these results. Since virtually all retirees are tenured faculty, it is not surprising that by the end of the century the median age of tenured faculty under an XR scenario is two years more than under an NCR scenario. The tenure ratio is also highest under the XR scenario, peaking at 0.85 in 1992. Under the NCR scenario, the tenure ratio sises to 0.825 in 1992. This rather small effect on the tenure ratio is matched by a small effect on hiring. Over the entire 25 year period, the XR scenario results in an average of 550 fewer hires a year than under the baseline projection; that is an average reduction of less than 8%. The NCR scenario results in an average of only 245 more hires a year above the baseline; this represents, on average, about one new hire per institution every 5 or 6 years! Hence it appears that later retirement is not very detrimental to academia, but neither is early retirement very helpful.

The main reason for the robustness of hiring over the projection period to changes in retirement rates during the next five years is the unusually small number of faculty currently near retirement age. This is result of the low hiring levels in the early 1950's. Ten years from now this will no longer be true. In Table 5-4 we have listed

FIGURE 5-1

PROJECTIONS OF MEDIAN AGES OF TENURED AND NON-TENURED FACULTY: 1976-2000 ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

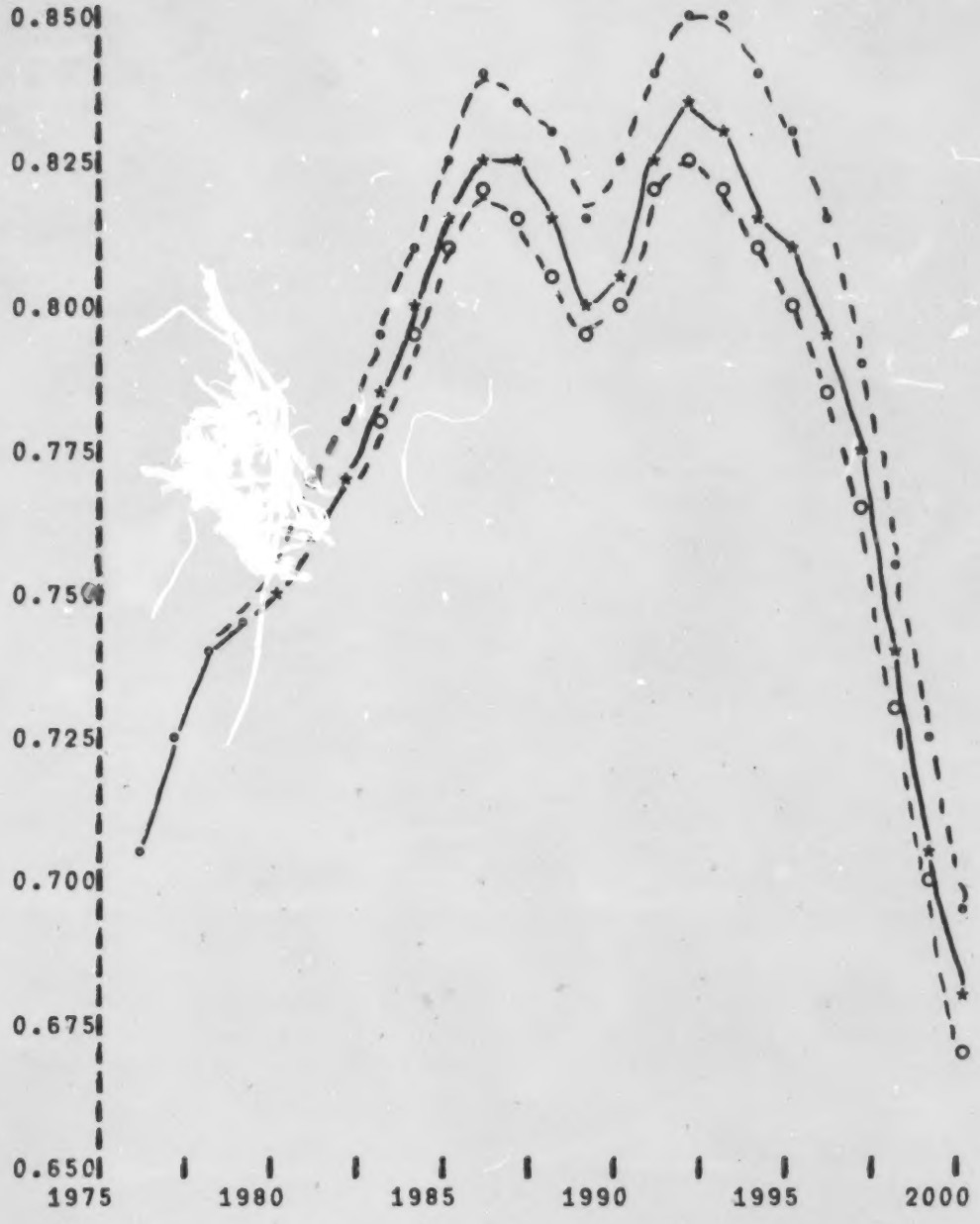


o - PROJECTION ASSUMING NO CHANGE IN RETIREMENT RATES
* - PROJECTION ASSUMING A MILD CHANGE IN RETIREMENT RATES
• - PROJECTION ASSUMING A LARGE CHANGE IN RETIREMENT RATES

THE UPPER THREE PLOTS ARE TENURED FACULTY, WHILE THE LOWER THREE PLOTS ARE THE NON-TENURED FACULTY

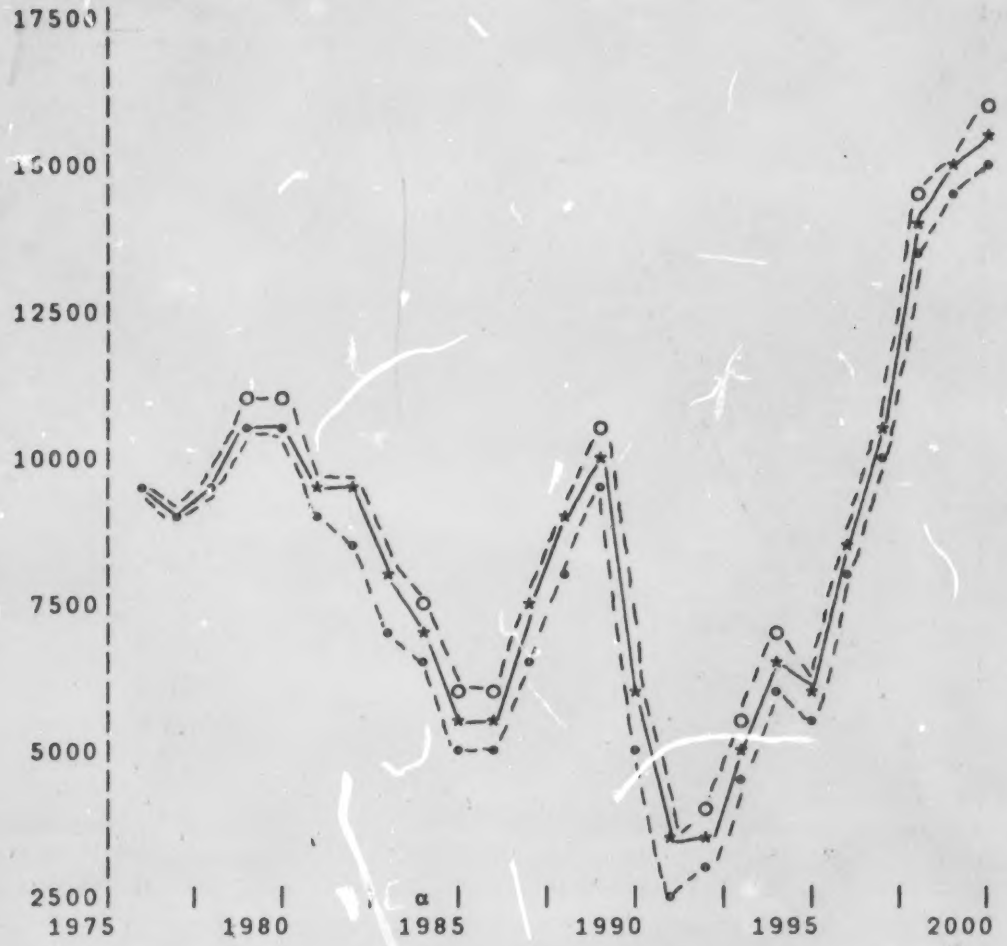
FIGURE 5-2

PROJECTIONS OF THE TENURE RATIO ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA



o - *PROJECTION ASSUMING NO CHANGE IN RETIREMENT RATES*
★ - *PROJECTION ASSUMING A MILD CHANGE IN RETIREMENT RATES*
• - *PROJECTION ASSUMING A LARGE CHANGE IN RETIREMENT RATES*

PROJECTIONS OF NEW DOCTORATES HIRES
ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION
OF MANDATORY RETIREMENT IN ACADEMIA



o - *PROJECTION ASSUMING NO CHANGE IN RETIREMENT RATES*
★ - *PROJECTION ASSUMING A MILD CHANGE IN RETIREMENT RATES*
• - *PROJECTION ASSUMING A LARGE CHANGE IN RETIREMENT RATES*

TABLE 5-4
PROJECTED RETIREMENTS
ASSUMING BASELINE SCENARIO

YEAR	*RETIREMENTS*	*YEAR*	*RETIREMENTS*
1976	1503	1988	1458
1977	1305	1989	1572
1978	1108	1990	1701
1979	986	1991	1838
1980	911	1992	1980
1981	839	1993	2120
1982	834	1994	2263
1983	927	1995	2406
1984	1027	1996	2535
1985	1131	1997	2656
1986	1241	1998	2766
1987	1355	1999	2854
		2000	2914

Source: Author's calculations.

the projected level of retirement under the baseline scenario. In 1988, when retirement rates are projected to be half what they are currently, the number of retirements is projected to be 31% higher than currently. This means that the size of the "retirement pool" has almost tripled. By 1998 the number of retirements is projected to be double the 1988 level. This suggests that the impact on hiring of any program that encourages faculty to retire early depends on when it is introduced.

To test this hypothesis, we have considered three possible "early retirement programs." The first program begins in 1979 and over a five-year period succeeds in changing retirement rates from the current values (the GK-rates) to new "ER-rates." The GK-rates and ER-rates are listed in Table 5-5 for comparison. The ER-rates are assumed to be a little smoother than the GK-rates because of the elimination of mandatory retirement. The ER-rates are presumed to hold after the

TABLE 5-5
Alternative Retirement Rates

Ages	59	60	61	62	63	64	65	66	67	68	69	70
GK-rates	.00	.01	.02	.03	.04	.05	.29	.18	.18	.20	.12	1.00
ER-rates	.00	.01	.02	.05	.10	.15	.20	.18	.16	.14	.12	1.00

early retirement program is fully implemented in 1983. The second scenario we have considered assumes that the early retirement program does not begin until 1983. Between 1978 and 1983 faculty begin retiring later, due to the abolition of mandatory retirement. After five years it is assumed that retirement rates have been changed to the ER-rates,

TABLE 5-6

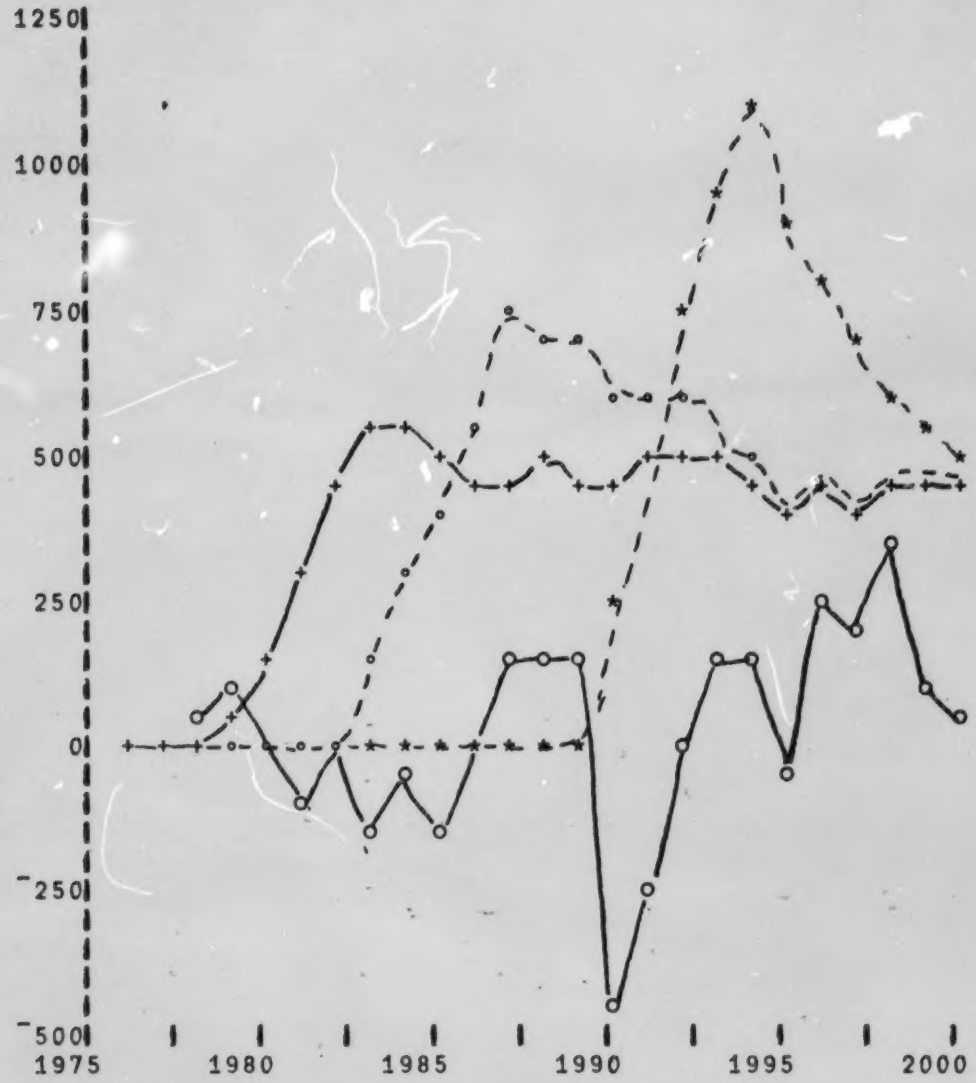
CHANGES FROM BASELINE HIRING DUE TO EARLY RETIREMENT POLICIES, ASSUMING DIFFERENT DATES FOR IMPLEMENTATION

YEAR	BASELINE HIRING	YEAR EARLY RETIREMENT POLICIES BEGIN 1979	1983	1990
1976	9327	0	0	0
1977	9222	0	0	0
1978	9633	0	0	0
1979	10642	51	0	0
1980	10698	173	0	0
1981	9488	307	0	0
1982	9294	459	0	0
1983	7790	534	131	0
1984	7197	528	277	0
1985	5609	503	424	0
1986	5661	471	566	0
1987	7315	468	726	0
1988	8852	476	708	0
1989	10170	473	680	6
1990	5817	457	617	246
1991	3351	482	586	503
1992	3542	520	577	747
1993	5073	497	523	954
1994	6473	466	475	1113
1995	5950	389	394	925
1996	8319	431	438	810
1997	10482	414	422	679
1998	14153	427	433	590
1999	14960	445	450	539
2000	15709	461	465	504
AVERAGE	8589	377	355	304

Source: Table 2-20 and author's calculations.

FIGURE 5-7

CHANGES FROM BASELINE HIRING DUE TO EARLY RETIREMENT POLICIES, ASSUMING DIFFERENT DATES FOR IMPLEMENTATION



o - *CHANGE IN BASELINE HIRING BETWEEN SUCCESSIVE YEARS DIVIDED BY 10*
\+ - *EARLY RETIREMENT IS IMPLEMENTED IN 1979*
◦ - *EARLY RETIREMENT IS IMPLEMENTED IN 1983*
* - *EARLY RETIREMENT IS IMPLEMENTED IN 1990*

which hold thereafter. The third scenario delays the introduction of early retirement until 1990. As with the other two scenarios, after five years it is assumed that the ER-rates are in effect. Table 5-6 shows how these three programs have changed the level of hiring.

As we expected, the third program has a much more powerful short-run than the other two. At its peak of effectiveness in 1995 the program frees more than 1,100 positions a year into which new doctorates can be placed. By comparison, the first program, in which early retirement is initiated in 1979, never provides more than 520 extra junior faculty positions in any year. The third program also has the virtue of increasing hiring the most during the early 1990's, precisely when enrollments are contracting the most. Figure 5-7 shows that the short-run decays after about five years to a long-run change in the level of new hiring of about 460 faculty a year. Early retirement programs can increase hiring by more than 30% only for a couple of years-- and achieving this requires careful timing.

When we combine this result with our conclusion from Section 4 as to the inappropriateness of using quit rates to increase doctorate hiring, we see that increasing faculty attrition is an ineffective way to counter the increased aging and "tenuring-in" of doctorate faculty that four-year institutions will experience during the next two decades. The best way to provide a smooth flow of young doctorates into academia is to either smooth faculty demand during this period or provide alternative "academic-like" employment until colleges are capable of absorbing an increased number of young faculty.

TABLE 5-8

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

TOTAL FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	13	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	14	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
	15	0.063	0.243	0.437	0.612	0.754	0.860	0.936	0.986	1.000	41.7	0.025
1980	13	0.071	0.200	0.370	0.551	0.702	0.838	0.931	0.989	1.000	43.6	0.032
	14	0.070	0.199	0.369	0.549	0.700	0.836	0.929	0.987	1.000	43.6	0.031
	15	0.068	0.196	0.365	0.546	0.696	0.832	0.925	0.985	1.000	43.7	0.030
1985	13	0.048	0.158	0.282	0.449	0.619	0.773	0.906	0.986	1.000	46.4	0.041
	14	0.046	0.153	0.275	0.443	0.612	0.766	0.899	0.980	1.000	46.6	0.040
	15	0.041	0.143	0.263	0.428	0.597	0.751	0.884	0.971	1.000	47.0	0.037
1990	13	0.056	0.151	0.257	0.379	0.538	0.710	0.864	0.980	1.000	48.9	0.038
	14	0.054	0.145	0.248	0.369	0.527	0.698	0.853	0.971	1.000	49.2	0.037
	15	0.049	0.133	0.229	0.347	0.504	0.675	0.829	0.955	1.000	49.9	0.034
1995	13	0.046	0.142	0.241	0.354	0.477	0.648	0.828	0.969	1.000	50.7	0.034
	14	0.044	0.135	0.230	0.339	0.461	0.631	0.810	0.954	1.000	51.3	0.033
	15	0.039	0.120	0.205	0.308	0.426	0.594	0.773	0.927	1.000	52.4	0.031
2000	13	0.104	0.252	0.363	0.466	0.565	0.678	0.828	0.966	1.000	46.7	0.036
	14	0.102	0.246	0.352	0.451	0.548	0.660	0.808	0.949	1.000	47.5	0.035
	15	0.098	0.234	0.331	0.421	0.511	0.620	0.767	0.919	1.000	49.4	0.033

NOTES;

1. *SCENARIO 13 ASSUMES THAT RETIREMENT RATES DO NOT CHANGE. SCENARIO 14 ASSUMES THAT RETIREMENT RATES ARE HALVED BY THE TIME THE LAW TAKES EFFECT IN 1982. SCENARIO 15 ASSUMES THAT ONCE THE LAW TAKES EFFECT IN 1982 ALL FACULTY RETIRE AT AGE 70.*

TABLE 5-9

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

TENURED FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	13	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	14	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
	15	0.008	0.098	0.281	0.494	0.675	0.812	0.916	0.983	1.000	45.1	0.020
1980	13	0.006	0.065	0.232	0.439	0.627	0.795	0.914	0.988	1.000	46.5	0.019
	14	0.006	0.065	0.231	0.438	0.626	0.793	0.911	0.986	1.000	46.5	0.018
	15	0.005	0.065	0.230	0.436	0.622	0.789	0.907	0.983	1.000	46.6	0.016
1985	13	0.004	0.053	0.161	0.346	0.545	0.728	0.888	0.984	1.000	48.8	0.024
	14	0.003	0.052	0.159	0.342	0.539	0.721	0.880	0.977	1.000	48.9	0.023
	15	0.003	0.049	0.154	0.334	0.528	0.707	0.864	0.966	1.000	49.2	0.021
1990	13	0.003	0.034	0.121	0.251	0.439	0.646	0.834	0.976	1.000	51.5	0.027
	14	0.003	0.032	0.117	0.245	0.430	0.635	0.822	0.965	1.000	51.7	0.026
	15	0.003	0.029	0.108	0.231	0.412	0.613	0.796	0.947	1.000	52.2	0.024
1995	13	0.002	0.035	0.107	0.222	0.365	0.569	0.789	0.962	1.000	53.4	0.033
	14	0.002	0.033	0.101	0.212	0.352	0.553	0.769	0.944	1.000	53.8	0.032
	15	0.001	0.029	0.089	0.191	0.325	0.519	0.730	0.914	1.000	54.6	0.030
2000	13	0.006	0.048	0.135	0.245	0.377	0.535	0.750	0.951	1.000	54.0	0.034
	14	0.006	0.046	0.127	0.232	0.359	0.513	0.725	0.927	1.000	54.6	0.033
	15	0.005	0.041	0.112	0.205	0.321	0.467	0.673	0.887	1.000	56.0	0.031

NOTES:

1. *SCENARIO 13 ASSUMES THAT RETIREMENT RATES DO NOT CHANGE. SCENARIO 14 ASSUMES THAT RETIREMENT RATES ARE HALVED BY THE TIME THE LAW TAKES EFFECT IN 1982. SCENARIO 15 ASSUMES THAT ONCE THE LAW TAKES EFFECT IN 1982 ALL FACULTY RETIRE AT AGE 70.*

TABLE 5-10

PROJECTED EVOLUTION OF DOCTORATE FACULTY ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

NON-TENURED FAC→LTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	13	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	14	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
	15	0.183	0.561	0.781	0.869	0.927	0.965	0.980	0.993	1.000	34.1	0.034
1980	13	0.278	0.630	0.813	0.908	0.940	0.972	0.985	0.992	1.000	32.9	0.073
	14	0.277	0.629	0.812	0.908	0.940	0.972	0.985	0.991	1.000	32.9	0.073
	15	0.273	0.625	0.810	0.906	0.939	0.971	0.985	0.991	1.000	33.0	0.073
1985	13	0.248	0.636	0.829	0.919	0.957	0.978	0.989	0.996	1.000	33.1	0.121
	14	0.244	0.631	0.826	0.917	0.955	0.977	0.989	0.996	1.000	33.1	0.120
	15	0.236	0.621	0.819	0.912	0.952	0.975	0.987	0.995	1.000	33.3	0.120
1990	13	0.282	0.653	0.838	0.929	0.963	0.986	0.992	0.998	1.000	32.7	0.084
	14	0.282	0.651	0.836	0.928	0.961	0.985	0.992	0.997	1.000	32.7	0.084
	15	0.280	0.646	0.830	0.923	0.958	0.982	0.990	0.996	1.000	32.8	0.084
1995	13	0.235	0.597	0.811	0.913	0.954	0.983	0.993	0.997	1.000	33.6	0.038
	14	0.235	0.594	0.808	0.911	0.953	0.982	0.992	0.997	1.000	33.6	0.038
	15	0.233	0.588	0.803	0.907	0.949	0.980	0.991	0.996	1.000	33.7	0.038
2000	13	0.316	0.692	0.856	0.941	0.971	0.989	0.996	0.999	1.000	32.2	0.039
	14	0.318	0.695	0.857	0.942	0.972	0.989	0.995	0.999	1.000	32.1	0.039
	15	0.324	0.701	0.859	0.943	0.972	0.989	0.995	0.998	1.000	32.0	0.039

NOTES:

1. *SCENARIO 13 ASSUMES THAT RETIREMENT RATES DO NOT CHANGE. SCENARIO 14 ASSUMES THAT RETIREMENT RATES ARE HALVED BY THE TIME THE LAW TAKES EFFECT IN 1982. SCENARIO 15 ASSUMES THAT ONCE THE LAW TAKES EFFECT IN 1982 ALL FACULTY RETIRE AT AGE 70.*

TABLE 5-11

PROJECTED EVOLUTION OF DOCTORATE FACULTY
ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION
OF MANDATORY RETIREMENT IN ACADEMIA

OTHER STATISTIC[

		1976	1980	1985	1990	1995	2000
TENURE	13	0.687	0.761	0.820	0.811	0.809	0.684
RATIO	14	0.687	0.763	0.825	0.817	0.818	0.691
	15	0.687	0.767	0.836	0.832	0.837	0.708
PROMOTION	13	0.193	0.134	0.111	0.117	0.102	0.094
RATE	14	0.193	0.135	0.111	0.117	0.102	0.094
	15	0.193	0.136	0.113	0.118	0.102	0.092
TURNOVER	13	0.049	0.053	0.029	0.031	0.033	0.076
RATE	14	0.049	0.052	0.028	0.029	0.032	0.075
	15	0.049	0.049	0.024	0.026	0.029	0.073
TOTAL	13	188561	207255	203258	198142	185729	209065
FACULTY	14	188561	207255	203258	198142	185729	209065
	15	188561	207255	203258	198142	185729	209065

NOTES:

1. SCENARIO 13 ASSUMES THAT RETIREMENT RATES DO NOT CHANGE. SCENARIO 14 ASSUMES THAT RETIREMENT RATES ARE HALVED BY THE TIME THE LAW TAKES EFFECT IN 1982. SCENARIO 15 ASSUMES THAT ONCE THE LAW TAKES EFFECT IN 1982 ALL FACULTY RETIRE AT AGE 70.
2. THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.

TABLE 5-12

PROJECTIONS OF NEW DOCTORATES HIRED ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

YEAR	NO RESPONSE	MILD RESPONSE (BASELINE)	EXTREME RESPONSE
1976	0.0	9327	0.0
1977	0.0	9222	-0.0
1978	0.7	9633	-1.5
1979	1.2	10642	-2.7
1980	1.8	10698	-4.2
1981	2.7	9488	-7.1
1982	3.6	9294	-6.8
1983	4.0	7790	-8.1
1984	4.3	7197	-8.9
1985	5.6	5609	-11.8
1986	5.5	5661	-11.9
1987	3.8	7315	-9.4
1988	3.2	8852	-7.7
1989	2.7	10170	-6.4
1990	5.2	5817	-11.1
1991	9.0	3351	-19.0
1992	10.2	3542	-20.8
1993	6.8	5073	-14.0
1994	4.8	6473	-10.0
1995	3.9	5960	-8.2
1996	3.1	8319	-6.7
1997	2.2	10482	-4.7
1998	1.6	14153	-3.5
1999	1.6	14960	-3.4
2000	1.6	15709	-3.3

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

TABLE 5-13

PROJECTIONS OF THE TENURE RATIO ASSUMING ALTERNATIVE RESPONSES TO THE ELIMINATION OF MANDATORY RETIREMENT IN ACADEMIA

YEAR	NO RESPONSE	MILD RESPONSE (BASELINE)	EXTREME RESPONSE
1976	0.0	0.703	0.0
1977	0.0	0.724	0.0
1978	0.0	0.738	0.1
1979	-0.1	0.745	0.3
1980	-0.2	0.751	0.5
1981	-0.4	0.762	0.9
1982	-0.5	0.772	1.1
1983	-0.6	0.786	1.3
1984	-0.7	0.799	1.4
1985	-0.7	0.814	1.5
1986	-0.8	0.825	1.6
1987	-0.8	0.823	1.7
1988	-0.8	0.813	1.8
1989	-0.8	0.800	1.9
1990	-0.9	0.807	1.9
1991	-0.9	0.825	1.9
1992	-1.0	0.833	2.1
1993	-1.1	0.829	2.3
1994	-1.2	0.817	2.5
1995	-1.2	0.810	2.5
1996	-1.2	0.796	2.5
1997	-1.2	0.773	2.5
1998	-1.2	0.738	2.5
1999	-1.2	0.706	2.4
2000	-1.2	0.678	2.4

NOTES:

1. *COLUMNS 2 AND 4 ARE PERCENTAGE DEVIATIONS FROM THE BASELINE PROJECTION GIVEN IN COLUMN 3*

6. Projections of Doctorate Women in Academia

American colleges are presently facing a moral challenge to increase the participation of women and minorities at all levels of academic life. This challenge is made all the more urgent by the legal prodding of Title VII of the Civil Rights Act of 1964, which bars discrimination by race or sex in all aspects of employment; by the 1972 Ammendments to the Education Act of 1967, which extends the provisions of Title VII to academic institutions; by Executive order 11234, which requires all federal contractors-- including universities and colleges-- to establish "affirmative action" goals to recruit women and minorities; by the Affirmative Action Guidelines issued by the Office of Civil Rights , which are becoming the rules determining compliance with both the executive order and Title VII; by the numerous court suits by organizations such as the Women's Equity Action League, as well as individual women, charging specific colleges and universities with consistent patterns of sex discrimination; by the Supreme Court's ruling(s) in the Bakke case affirming the right of colleges to use race and sex as criteria for admissions; and by the Supreme Court's ruling in U.S. vs A.T.&T. affirming the constitutionality of the enforcement provisions of Title VII. The list could be much longer.

Women are demanding the right to be considered equal partners to men on faculties. Considering the "steady state" conditions academia will face over the rest of this century, however, how much progress can colleges and universities be expected to make in bringing more women into full-time academic positions? To answer this question requires us to hypothesize the consequences of "good faith efforts"

on the part of colleges and universities to eliminate discrimination in the hiring, retention, promotion, and remuneration of their faculty. We will take a "quota" approach and suppose that honest attempts to treat women as equals would result in: (1) the sex ratio among new hires equaling the sex ratio in the pool of new doctorates seeking academic employment, and (2) the same age-specific probabilities of promotion, quitting and retirement for men and women. With these assumptions, once we obtain projections of the future sex ratio among new doctorates and project our many probabilities, we can obtain separate projections of the demographic evolution of men and women faculty.

From the previous four sections we have "baseline" assumptions on promotion rates, quit rates, retirement rates and total faculty demand which together represent a "likely scenario." The 1975 Carnegie Survey of faculty provides not only age distribution by sex, which are listed below, but also an estimate of the fraction of women among doctorate faculty in 1975: 12.1%.

TABLE 6-1

AGE DISTRIBUTIONS OF DOCTORATE FACULTY IN 1975 BY SEX

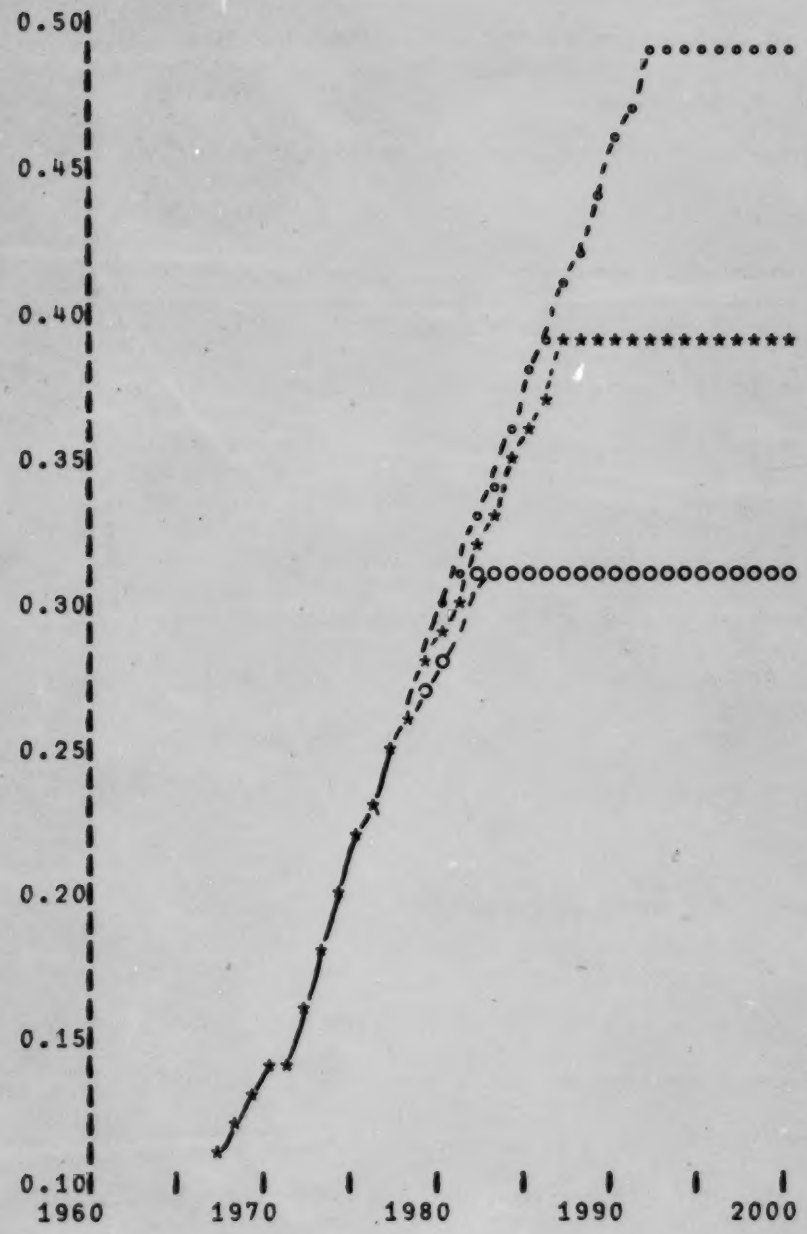
AGES	MEN	WOMEN
26-30	0.046	0.184
31-35	0.164	0.295
36-40	0.192	0.210
41-45	0.181	0.126
46-50	0.151	0.080
51-55	0.114	0.054
56-60	0.081	0.034
61-65	0.055	0.014
66-70	0.015	0.003

SOURCE: COMPUTED BY THE AUTHOR FROM DATA SUPPLIED BY THE CARNEGIE COMMISION ON HIGHER EDUCATION.

All that we need is a projection of the sex ratio among new doctorates. With this series, together with our baseline projection of total faculty hiring, we can project hires of doctorate women and proceed to calculate the evolving sex ratio implied by our assumptions. The Doctorate Records file maintained by the National Research Council provides us with excellent data on the characteristcs of new doctorates at U.S. universities. According to this file, over the last ten years the fraction of doctorates awarded to women has been increasing by about 8% a year; since 1967, the fraction has doubled to 24.8%. Since the future change in this ratio is highly conjectural, we have decided to construct three projections: (1) a "pessimistic" projection in which the fraction of women among new doctorates increases only until 1983 and then levels off to a constant value of 0.308; (2) a "middle-of-the road" projection in which we assume that the fraction increases at its current rate for 10 years, leveling off in 1988 at a value of 0.388; (3) an "optimistic" projection that assumes the fraction increases steadily at its current rate for 15 years, leveling off in 1993 at a value of 0.488.

The three projections are shown in Figure 6-2. The implied projections of hires of doctorate women are found in Table 6-3. Because hiring is so low, there is very little difference in these three series. The projected sex ratios, which have been calculated for the tenured and non-tenured faculty separately as well as for the total faculty, are shown in Figures 6-4, 6-5 and 6-6. Under the optimistic scenario, despite the low hiring projected, the fraction of women in academia at the end of the century is projected to be

FIGURE 6-2
PROPORTION OF NEW DOCTORATES WHO ARE WOMEN
1967-2000



PLOTS FOR THE YEARS 1978-2000 ARE PROJECTIONS

SOURCES: NATIONAL RESEARCH COUNCIL, DOCTORATES RECIPIENTS FROM UNITED STATES UNIVERSITIES: SUMMARY REPORT. FEBRUARY, 1977.

TABLE 6-3

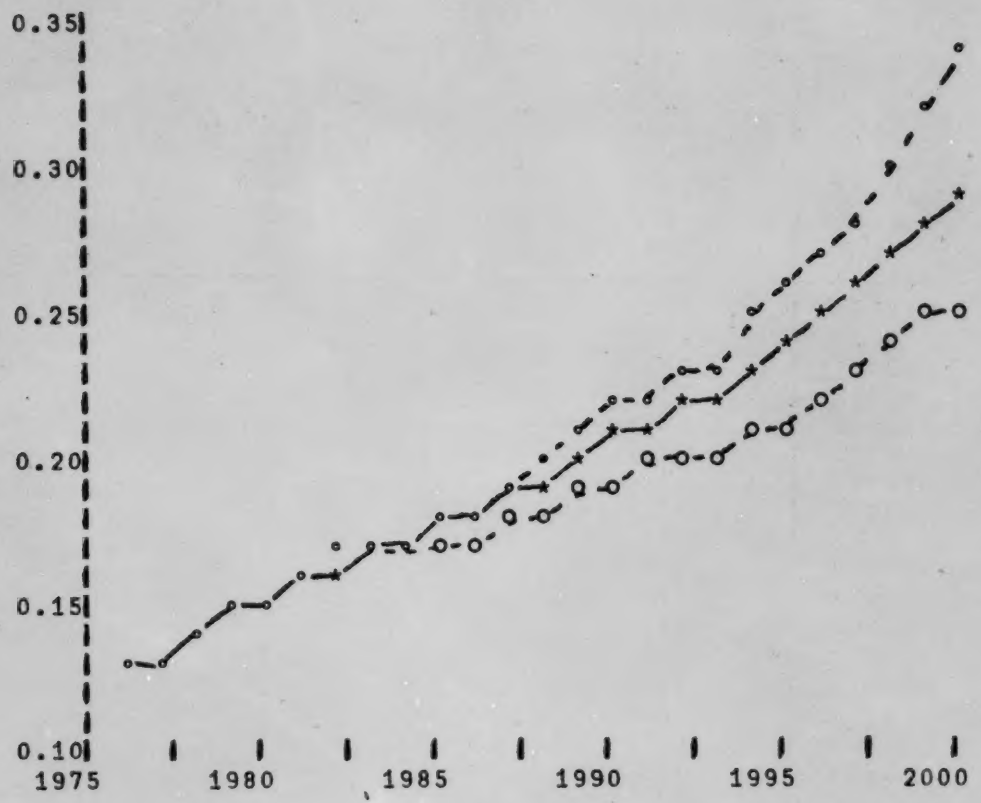
ALTERNATIVE PROJECTIONS OF HIRES OF NEW WOMEN DOCTORATES UNDER AFFIRMATIVE ACTION GUIDELINES

YEAR	TOTAL NEW HIRES	ASSUMED ALTERNATIVE STEADY-STATE FRACTION OF NEW DOCTORATES WHO ARE WOMEN		
		0.308	0.388	0.488
1976	9327	2173	2173	2173
1977	9222	2290	2290	2290
1978	9633	2505	2524	2543
1979	10642	2895	2937	2980
1980	10698	3038	3102	3167
1981	9488	2808	2884	2960
1982	9294	2863	2956	3049
1983	7790	2399	2586	2680
1984	7197	2217	2490	2591
1985	5609	1728	2019	2109
1986	5661	1744	2117	2219
1987	7315	2253	2838	2984
1988	8852	2726	3435	3753
1989	10170	3132	3946	4475
1990	5817	1792	2257	2653
1991	3351	1032	1300	1582
1992	3542	1091	1374	1729
1993	5073	1563	1968	2476
1994	6473	1994	2511	3159
1995	5960	1836	2313	2909
1996	8319	2562	3228	4060
1997	10482	3228	4067	5115
1998	14153	4359	5491	6907
1999	14960	4608	5804	7300
2000	15709	4839	6095	7666

Source: Table 2-20 and author's calculations.

FIGURE 6-4

PROJECTED SEX RATIO AMONG DOCTORATE FACULTY ASSUMING DIFFERENT SEX RATIOS AMONG NEW DOCTORATES AND ASSUMING EQUAL PROMOTION AND RETENTION RATES FOR MEN AND WOMEN



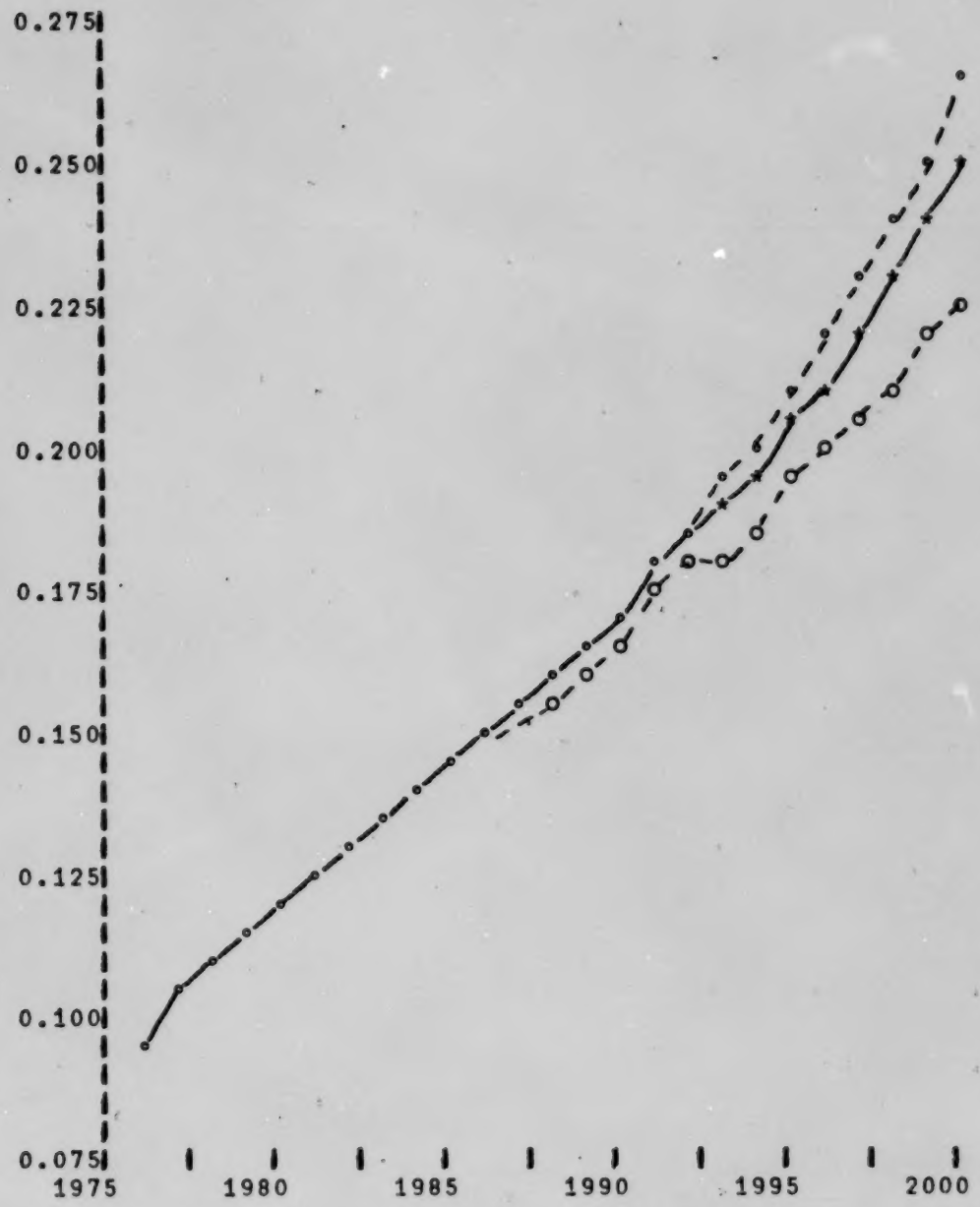
o - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.308.

* - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.388.

∘ - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.488.

FIGURE 6-5

PROJECTED SEX RATIO AMONG TENURED FACULTY ASSUMING DIFFERENT SEX RATIOS AMONG NEW DOCTORATES AND ASSUMING EQUAL PROMOTION AND RETENTION RATES FOR MEN AND WOMEN



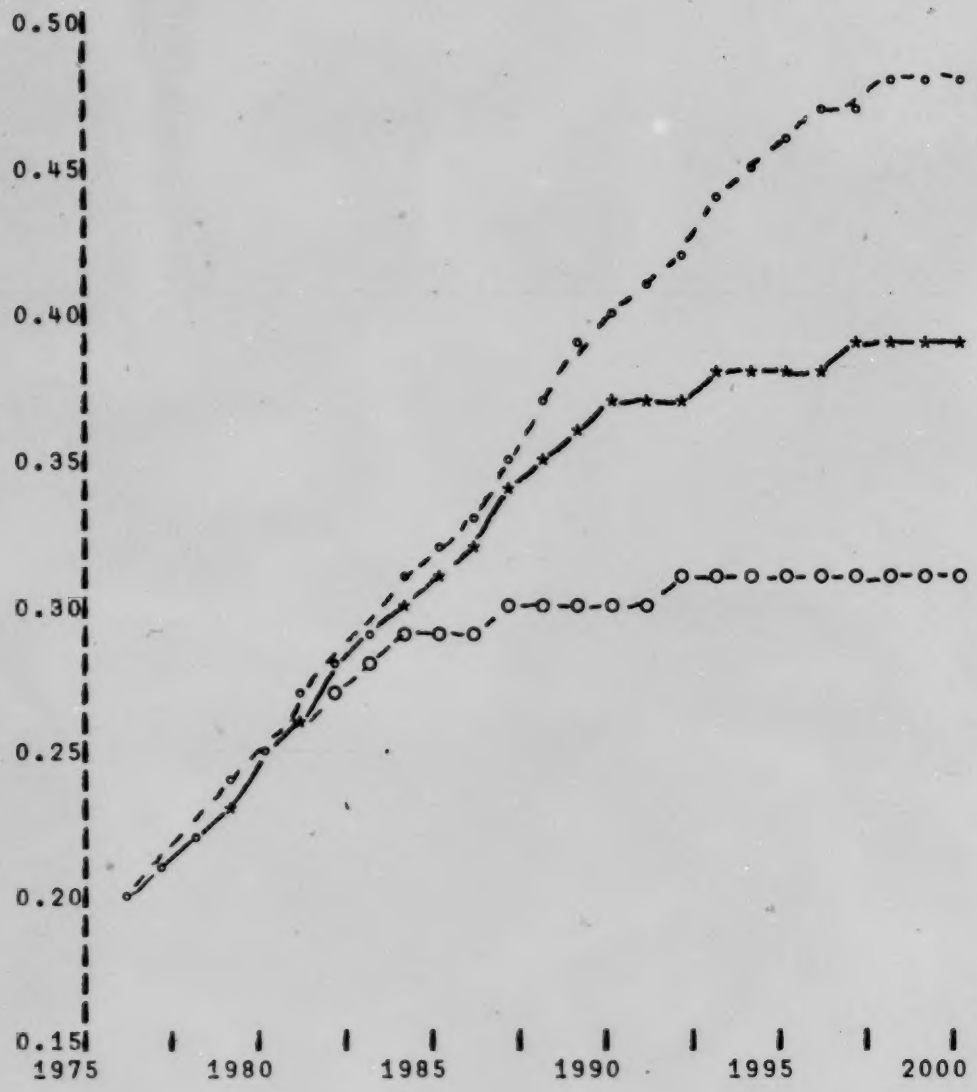
o - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO 0.308.*

* - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO 0.388.*

• - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO 0.488.*

FIGURE 6-6

PROJECTED SEX RATIO AMONG NON-TENURED FACULTY ASSUMING DIFFERENT SEX RATIOS AMONG NEW DOCTORATES AND ASSUMING EQUAL PROMOTION AND RETENTION RATES FOR MEN AND WOMEN



o - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.308.

* - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.388.

o - *ASSUMES THAT THE SEX RATIO AMONG NEW DOCTORATES RISES TO* 0.488.

three time higher than it is currently! Even under the "pessimistic" scenario the fraction is projected to double. This would seem to indicate that in the recent past, when hiring levels were much higher than we are projecting, men and women had very different hiring and quit rates. Under the "optimistic" scenario. parity between non-tenured men and women is almost achieved by 1998. Not surprisingly, the fraction of tenured faculty who are women increases much more slowly. Yet by 2000 the fraction is almost three time its value in 1975.

Table 6-7 shows that although their age distribution is much younger than that of the men, the median age of the women faculty increases by from 6 to 9 years from its value in 1976; Table 6-8 shows that this is due almost entirely to the "aging" of the pool of tenured doctorate women. Table 6-10 shows that the fraction of women with tenure rises to betwen 0.66 and 0.73 by 1995. Hence the basic demographic trends are the same for men and women. Table 6-10 also shows that some summary statistics can be misleading. Even though we know that men and women have the same age-specific promotion rates, the mean promotion rate of women in 1976 is 18.4% , compared to a mean rate for men of 24.1%. However, once the age distributions of non-tenured men and women become more similiar, which occurs by the early 1980s, the mean promotion rates for the two groups converge.

TABLE 6-7

PROJECTED EVOLUTION OF ACADEMIC WOMEN WITH DOCTORATES ASSUMING DIFFERENT RATES OF ENTRY OF DOCTORATE WOMEN INTO ACADEMIA AND EQUAL RATES OF PROMOTION AND RETENTION FOR MEN AND WOMEN

TOTAL WOMEN FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	16	0.184	0.478	0.688	0.815	0.895	0.949	0.983	0.997	1.000	35.4	0.028
	17	0.184	0.478	0.688	0.815	0.895	0.949	0.983	0.997	1.000	35.4	0.028
	18	0.184	0.478	0.688	0.815	0.895	0.949	0.983	0.997	1.000	35.4	0.028
1980	16	0.197	0.422	0.640	0.783	0.874	0.938	0.975	0.996	1.000	36.7	0.038
	17	0.199	0.424	0.641	0.784	0.875	0.939	0.975	0.996	1.000	36.6	0.038
	18	0.201	0.426	0.643	0.785	0.875	0.939	0.975	0.996	1.000	36.6	0.038
1985	16	0.129	0.335	0.529	0.687	0.816	0.909	0.963	0.991	1.000	39.3	0.050
	17	0.140	0.349	0.540	0.694	0.820	0.911	0.964	0.991	1.000	39.0	0.052
	18	0.144	0.355	0.546	0.698	0.822	0.912	0.964	0.991	1.000	38.9	0.052
1990	16	0.134	0.290	0.456	0.596	0.732	0.864	0.944	0.987	1.000	41.5	0.037
	17	0.157	0.329	0.494	0.625	0.751	0.874	0.948	0.988	1.000	40.2	0.039
	18	0.170	0.347	0.511	0.639	0.760	0.879	0.950	0.988	1.000	39.6	0.041
1995	16	0.098	0.243	0.388	0.515	0.648	0.792	0.912	0.978	1.000	44.4	0.023
	17	0.112	0.277	0.434	0.559	0.681	0.811	0.921	0.980	1.000	42.4	0.023
	18	0.130	0.310	0.469	0.590	0.705	0.825	0.926	0.982	1.000	41.0	0.023
2000	16	0.193	0.368	0.499	0.590	0.683	0.792	0.895	0.974	1.000	40.0	0.027
	17	0.209	0.399	0.541	0.637	0.725	0.821	0.910	0.977	1.000	38.4	0.026
	18	0.230	0.438	0.586	0.679	0.759	0.844	0.921	0.980	1.000	36.9	0.027

NOTES;

1. *PROJECTION* 16 *ASSUMES THAT THE FRACTION OF NEW DOCTORATES WHO ARE WOMEN PEAKS AT* 0.308 *IN* 1983. *PROJECTION* 17 *ASSUMES THAT THE FRACTION OF WOMEN AMONG NEW DOCTORATES CONTINUES TO CLIMB UNTIL* 1988, *PEAKING AT* 0.388. *PROJECTION* 18 *ASSUMES THAT THE FRACTION CONTINUES TO CLIMB UNTIL* 1993, *PEAKING AT* 0.488.

TABLE 6-8

PROJECTED EVOLUTION OF ACADEMIC WOMEN WITH DOCTORATES ASSUMING DIFFERENT RATES OF ENTRY OF DOCTORATE WOMEN INTO ACADEMIA AND EQUAL RATES OF PROMOTION AND RETENTION FOR MEN AND WOMEN

TENURED WOMEN FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	16	0.041	0.222	0.459	0.672	0.812	0.900	0.965	0.993	1.000	40.8	0.021
	17	0.041	0.222	0.459	0.672	0.812	0.900	0.965	0.993	1.000	40.8	0.021
	18	0.041	0.222	0.459	0.672	0.812	0.900	0.965	0.993	1.000	40.8	0.021
1980	16	0.019	0.172	0.439	0.652	0.799	0.902	0.959	0.993	1.000	41.2	0.013
	17	0.019	0.172	0.439	0.652	0.799	0.902	0.959	0.993	1.000	41.2	0.013
	18	0.019	0.172	0.439	0.652	0.799	0.902	0.959	0.993	1.000	41.2	0.013
1985	16	0.012	0.135	0.341	0.553	0.736	0.870	0.948	0.987	1.000	43.6	0.017
	17	0.013	0.137	0.343	0.555	0.737	0.870	0.948	0.987	1.000	43.6	0.017
	18	0.013	0.139	0.345	0.556	0.738	0.871	0.948	0.987	1.000	43.6	0.017
1990	16	0.010	0.081	0.248	0.427	0.618	0.807	0.921	0.981	1.000	47.0	0.016
	17	0.012	0.090	0.260	0.438	0.626	0.811	0.923	0.982	1.000	46.7	0.016
	18	0.012	0.093	0.265	0.443	0.629	0.812	0.923	0.982	1.000	46.6	0.015
1995	16	0.004	0.070	0.195	0.343	0.520	0.715	0.880	0.970	1.000	49.5	0.017
	17	0.005	0.084	0.223	0.375	0.544	0.729	0.886	0.972	1.000	48.9	0.016
	18	0.006	0.092	0.237	0.390	0.556	0.737	0.889	0.973	1.000	48.5	0.016
2000	16	0.013	0.082	0.210	0.337	0.482	0.659	0.828	0.957	1.000	50.5	0.019
	17	0.015	0.094	0.240	0.381	0.525	0.689	0.843	0.961	1.000	49.2	0.017
	18	0.017	0.110	0.270	0.414	0.554	0.710	0.854	0.963	1.000	48.1	0.016

NOTES:

1. *PROJECTION 16 ASSUMES THAT THE FRACTION OF NEW DOCTORATES WHO ARE WOMEN PEAKS AT 0.308 IN 1983. PROJECTION 17 ASSUMES THAT THE FRACTION OF WOMEN AMONG NEW DOCTORATES CONTINUES TO CLIMB UNTIL 1988, PEAKING AT 0.388. PROJECTION 18 ASSUMES THAT THE FRACTION CONTINUES TO CLIMB UNTIL 1993, PEAKING AT 0.488.*

TABLE 6-9

PROJECTED EVOLUTION OF ACADEMIC WOMEN WITH DOCTORATES ASSUMING DIFFERENT RATES OF ENTRY OF DOCTORATE WOMEN INTO ACADEMIA AND EQUAL RATES OF PROMOTION AND RETENTION FOR MEN AND WOMEN

NON-TENURED WOMEN FACULTY

YEAR		AGE DISTRIBUTION ≤30	≤35	≤40	≤45	≤50	≤55	≤60	≤65	≤70	MEDIAN AGE	ATTRITION RATE
1976	16	0.318	0.719	0.904	0.948	0.973	0.995	0.999	1.000	1.000	32.0	0.035
	17	0.318	0.719	0.904	0.948	0.973	0.995	0.999	1.000	1.000	32.0	0.035
	18	0.318	0.719	0.904	0.948	0.973	0.995	0.999	1.000	1.000	32.0	0.035
1980	16	0.458	0.790	0.935	0.976	0.985	0.992	0.999	1.000	1.000	30.5	0.075
	17	0.460	0.792	0.936	0.976	0.985	0.992	0.999	1.000	1.000	30.5	0.075
	18	0.463	0.793	0.936	0.976	0.985	0.992	0.999	1.000	1.000	30.4	0.075
1985	16	0.385	0.774	0.942	0.980	0.990	0.994	0.997	1.000	1.000	31.2	0.122
	17	0.401	0.784	0.946	0.981	0.991	0.994	0.997	1.000	1.000	31.0	0.122
	18	0.404	0.787	0.947	0.982	0.991	0.995	0.997	1.000	1.000	31.0	0.123
1990	16	0.421	0.771	0.935	0.983	0.993	0.997	0.998	0.999	1.000	30.9	0.084
	17	0.438	0.790	0.945	0.986	0.994	0.997	0.998	0.999	1.000	30.7	0.085
	18	0.451	0.800	0.949	0.987	0.995	0.997	0.998	0.999	1.000	30.5	0.086
1995	16	0.350	0.707	0.904	0.972	0.991	0.997	0.999	0.999	1.000	32.0	0.038
	17	0.355	0.717	0.912	0.977	0.993	0.998	0.999	1.000	1.000	31.9	0.038
	18	0.374	0.737	0.923	0.981	0.994	0.998	0.999	1.000	1.000	31.6	0.038
2000	16	0.471	0.808	0.944	0.980	0.993	0.998	0.999	1.000	1.000	30.3	0.039
	17	0.472	0.810	0.947	0.983	0.994	0.999	1.000	1.000	1.000	30.3	0.039
	18	0.476	0.817	0.952	0.985	0.995	0.999	1.000	1.000	1.000	30.3	0.039

NOTES:

1. *PROJECTION 16 ASSUMES THAT THE FRACTION OF NEW DOCTORATES WHO ARE WOMEN PEAKS AT 0.308 IN 1983. PROJECTION 17 ASSUMES THAT THE FRACTION OF WOMEN AMONG NEW DOCTORATES CONTINUES TO CLIMB UNTIL 1988, PEAKING AT 0.388. PROJECTION 18 ASSUMES THAT THE FRACTION CONTINUES TO CLIMB UNTIL 1993, PEAKING AT 0.488.*

TABLE 6-10

PROJECTED EVOLUTION OF ACADEMIC WOMEN WITH DOCTORATES ASSUMING DIFFERENT RATES OF ENTRY OF DOCTORATE WOMEN INTO ACADEMIA AND EQUAL RATES OF PROMOTION AND RETENTION FOR MEN AND WOMEN

OTHER STATISTICS

		1976	1980	1985	1990	1995	2000
TENURE RATIO	16	0.484	0.594	0.687	0.696	0.728	0.606
	17	0.484	0.592	0.673	0.659	0.694	0.574
	18	0.484	0.590	0.667	0.641	0.662	0.536
PROMOTION RATE	16	0.184	0.125	0.108	0.117	0.102	0.094
	17	0.184	0.124	0.105	0.114	0.102	0.094
	18	0.184	0.124	0.105	0.111	0.099	0.093
TURNOVER RATE	16	0.095	0.097	0.049	0.047	0.046	0.092
	17	0.095	0.098	0.056	0.055	0.052	0.099
	18	0.095	0.100	0.058	0.062	0.061	0.109
TOTAL FACULTY	16	22814	31414	34946	38269	39855	52800
	17	22814	31533	35799	41249	44057	61300
	18	22814	31652	36233	42845	47527	70275

NOTES:

1. *PROJECTION 16 ASSUMES THAT THE FRACTION OF NEW DOCTORATES WHO ARE WOMEN PEAKS AT 0.308 IN 1983. PROJECTION 17 ASSUMES THAT THE FRACTION OF WOMEN AMONG NEW DOCTORATES CONTINUES TO CLIMB UNTIL 1988, PEAKING AT 0.388. PROJECTION 18 ASSUMES THAT THE FRACTION CONTINUES TO CLIMB UNTIL 1993, PEAKING AT 0.488.*
2. *THE TENURE RATIO IS THE FRACTION OF DOCTORATE FACULTY WITH TENURE. THE PROMOTION RATE IS THE FRACTION ON NON-TENURED FACULTY PROMOTED TO TENURE RANK IN A GIVEN YEAR. THE TURNOVER RATE IS NEW HIRES AS FRACTION OF THE TOTAL DOCTORATE FACULTY.*

7. Conclusion

We have presented projections of faculty hiring, the tenure ratio, and the age distribution of tenured and non-tenured faculty under a variety of assumptions as to the severity of the contraction in enrollments and the responses of institutions to this contraction. We proceeded by assigning to every individual at every date in our projection period a probability of staying in academia for one more year and, if not tenured at that date, a probability of receiving tenure by the following year. These probabilities were assumed to be the same for all individuals who were of the same age, had begun teaching in academia in the same year, and who had the same tenure status (i.e., were tenured or not). Using these probabilities we calculated every year the expected number of quits, retirements, deaths, new hirings and promotions to tenure for each of these cohorts. From these flows we could estimate the number of tenured and non-tenured faculty in the following year, by both age and years in academia. Working recursively, we traced out the evolution of the faculty age distribution, the tenure ratio, and hirings required to replace those who left and to account for growth (or contraction).

Our baseline projection, which assumes moderate changes in the transition probabilities, shows a large increase in the tenure ratio (21% over 20 years) and the median age of tenured faculty (25% over 20 years). The evolution of the tenure ratio is very robust to the evolution of the quit rates of both the tenured and non-tenured faculty. In our alternative projections, the tenure ratio never differs by more than 2% from the baseline projection. The tenure ratio is also very robust to the evolution of the retirement rates. The median age of non-tenured faculty displays great insensitivity to all of our parameters; however the median age of the

tenured faculty shows some sensitivity to assumptions as to the quit rate of tenured faculty and retirement rates. Our early retirement scenario, for example, results in the median age of faculty in 2000 being 2 years less than under the baseline scenario.

The trough in the hiring of doctorate faculty is projected to be 1992-93. Should the doctorate faculty-student ratio rise by 10% from its 1976 value of 1:32, 1992 hires are projected to be 4325; a 10% fall in the ratio reduces hiring in 1992 to 2200. A 10% increase in the rate of tenured faculty departures yields a 2.8% increase in the level of 1992 hiring, while a 10% increase in the non-tenured faculty quit rate produces a 3.9% increase in hiring. Changes in the rate of promotion have a small impact on hiring in any year, but a strong effect on the tenure ratio. The early retirement program we tried increases long-run hiring by only about 460 positions a year. In no year is hiring boosted by more than 1,100. An unexpected result is that delaying the introduction of early retirement until 1990 is preferable to beginning now. In either case, hiring levels in the 1980s are about the same; however, by delaying early retirement a decade one provides for a "hiring cushion" for a second fall in enrollments (hence in faculty demand) projected for 1990-95. In addition to the basic dynamics of our modeling of faculty, we presented, in our introduction, a number of questions we claimed our paper would shed light on. Some have already been treated above, and those remaining we can look at now:

(1) In order for tenure "quotas" to be superior to early retirement programs for halting the rise in the tenure ratio, it appears they have to be very low quotas. If such low promotion rates imply actually forcing junior faculty to change employers every few years, this could succeed in clearing the market of the best young talent. If they are not forced to leave, then

the meaning of the word tenure becomes vague. Yet, early retirement appears to be a weak policy either for insuring faculty vitality or for improving the job market for new doctorates who wish to work in academia.

(2) If affirmative action programs are successful, one should observe the same rates of hiring, promotion and termination for women and minorities as one observes for white males. Hence, by carrying out the calculations we have made here for these two sub-populations separately--assuming the rates are the same as for the faculty as a whole--one can gauge the rates of change in the sex and race composition of academia to be expected under different assumptions on the formation of the pools of new doctorates seeking academic employment. We constructed some projections and found that, despite the low rate of hires projected for the next two decades, if women are treated equally with men, then the fraction of women in academia could be trebled by the end of the century. Furthermore, if the current rate of increase in the fraction of doctorates awarded to women continues unabated, then by 2000 non-tenured faculty would have almost equal numbers of men and women.

(3) Examination of the mean rates of promotion, retirement, and quitting in the baseline projection reveals that ignoring the age distribution would have resulted in a 50-100% underestimate in retirements for the years after 1990, and would have led to an average overestimate of over 20% for the number of promotions to tenure. Hence, ignoring age-specific probabilities of retirement, promotion, etc., leads to large errors.

(4) In many institutions, faculty denied tenure are not reappointed past their sixth year. The current very low quit rates of non-tenured faculty (2%) reveals that most of them find employment elsewhere. By ignoring inter-sectoral flows we have ignored this "re-hire" market for faculty entirely. Yet it is in this market that non-tenured faculty make

the decision to leave academia or not. Faculty in this market are also in direct competition with new doctorates, and different sectors of academia probably have different preferences between new doctorates and experienced (but unemployed) faculty. As an extreme example, imagine academia split up into two sectors, "research" schools and "teaching" schools. If teaching schools fill all of their positions from the "re-hire" market, then the growth and promotion rates of the research institutions completely determine the level of hiring of new doctorates. Our projections could then present a considerably distorted picture of the job prospects for new graduates in the future. Incorporating these inter-sectoral flows appears to be the most important extension to this work, and probably the most difficult.

NOTES

1. This was estimated from the number of respondents to the 1975 Carnegie Survey of U.S. Faculty who reported receiving their doctorate in 1974. This provides an estimate of the number of new hires of doctorates in 1974. Since the number of new faculty positions is not likely to change much between successive years, this is also an estimate of the number of new doctorate hires in 1975.
2. Other factors that would affect the demand on faculty teaching time, independently of the level of enrollment, are the number of teaching assistants and graders employed to help professors with course paperwork and individual instruction, the level of preparation of freshmen, and the degree of maturity and independence of students.
3. Professor Kuh has pointed out to us that G. S. Haggstrom also has produced projections of FTE enrollments. These are, on average, about 10% higher than Cartter's enrollment levels. The original series is found in his paper, "The Growth of Higher Education in the U.S." (unpublished manuscript), Carnegie Commission on Higher Education, Berkeley, 1971. These are also reported in Roy Radner and F. Balderston, "Academic Demand for New Ph.D.'s, 1970-1990: Its Sensitivity to Alternative Policies," Office of the Vice-President for Planning, University of California, Berkeley, 1971.
4. These estimates are based on an analysis of respondents to the 1975 Carnegie Survey of U.S. Faculty and Cartter's estimate of FTE student enrollments (Cartter [1976]).
5. Below are the equations we found predicted the date effects well for the two periods 1954-1964 and 1967-1973. First, let us define:

ΔE_t = change in degree-credit enrollments;

D_t = number of new doctorates granted during the year; and

$\ell n\, B_t$ = the natural logarithm of the promotion "date effects" estimated from our 1975 data;

then our two estimated equations are:

Period I: 1956-1964

$$\ell n\, B_t = -.3142 - \underset{(.0100)}{.0288}\,\frac{\Delta E_{t-2}}{D_{t-2}} + \underset{(.000044)}{.000178}\,\frac{\Delta E^2_{t-2}}{D_{t-2}}$$

$$R^2 = .796 \qquad \hat{\sigma}^2 = .008$$

Period II: 1967-1973

$$\ell n\, B_t = .218 + \underset{(.0013)}{.00407}\,\frac{\Delta E_{t-4}}{D_{t-4}}$$

$$R^2 = .658 \qquad \hat{\sigma}^2 = .045$$

Period II': 1967-1972

$$\ell n\, B_t = .249 + \underset{(.00024)}{.00328}\,\frac{\Delta E_{t-4}}{D_{t-4}}$$

$$R^2 = .978 \qquad \hat{\sigma}^2 = .0089$$

Sources of data:

B_t = estimated from 1975 Carnegie Survey

D_t = 1954-1960 from Earned Degrees Conferred, Office of Education, 1964-65, Table 4; 1961-1973 from Alan Cartter [1976], Table 5-5.

ΔE_t = 1954-1974: Office of Education, Biennial Survey of Higher Education and Projections of Educational Statistics, various issues.

6. The 1963 survey was conducted by the U.S. Office of Education, while the 1969 survey was conducted jointly by the Carnegie Commission on Higher Education and the American Council on Education.

7. These levels were chosen so that projected hires in 1976 would not be more than 10% above the estimated number of new doctorate faculty hired in 1974. The latter we were able to estimate by looking at the number of respondents in the 1975 Carnegie Survey who reported that they received their doctorate in 1974 and were employed full-time in 1974-75. If this group is under-represented in the sample, then we underestimate the number of 1974 hires and hence have probably underestimated the quit rates. Although these quit rates seem very low, one must remember that they are quit rates from academia, not separation rates from colleges; in particular note that faculty denied tenure at their first institution can try to obtain tenure elsewhere rather than quit teaching.

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APPENDIX

1. The Mathematics of Our Projections
2. Variances of the Projected Population Means
3. Estimation of the Model's Parameters

Appendix 1:

The Mathematics of Our Projections

As our starting point, we assume that each of the sources of flux in the future make-up of academia--the myriad decisions to grant tenure, to retire, to replace faculty and to leave for non-academic employment--is a random variable. We also assume that each of these decisions as well as the variable of when faculty will die are independent after conditioning them on just a few characteristics of the people making them. Since we must trace these determining variables over time, we will limit ourselves to only three: (1) years since birth, or "biological age," which we will denote by B(t); (2) years since beginning a full-time career in higher education with a doctorate, or "academic age," denoted by A(t); and (3) whether one is tenured or non-tenured, denoted by n(t). If we define E = B(t) - A(t), which is the biological age when one entered academia, then every individual still in academia at time t is characterized by E, A(t) and n(t). For each person, let us call the triplet E, A(t) and n(t) the "state" of the individual at time t. Our population is, then, characterized by the number of people in each state; we denote:

$T(i,j,t)$ = the number of people with $A(t) = i$, $E = j$ and $n(t)$ = "tenured"

$N(i,j,t)$ = the number of people with $A(t) = i$, $E = j$ and $n(t)$ = "non-tenured"

The probability model we intend to use is the Markovian model: the probability that the individual is in a given state at time t + s, given his "history" (i.e., the succession of states) up to time t, depends only on his state at time t.

This is not as strong an assumption as it appears. In the case of non-tenured faculty, the "history" of a person provides no more information than his current age and tenure status. In the case of tenured faculty, the only additional information in one's history is the age at which one received tenure. The latter could reflect one's level of academic brilliance, which in turn can be expected to influence one's movement within academia.

Since we know of no information that relates the likelihood of quitting or the timing of retirement to the age at which one first receives tenure, we assume no dependence. However, we saw above that this is equivalent to assuming that our stochastic process is Markovian.

Note that if every cohort of faculty (i.e., faculty with the same biological and academic age) has about the same distribution of levels of competence, then only a small error will result if we ignore competence. In the terminology of Markov theory, we are "lumping" over competence.

We have yet to ascribe a "state" to those faculty who leave academia in any year. Since they must be replaced, we will "identify" them with the persons hired to replace them. In our present work we will also assume that all the new hires have no academic work experience; hence, "quits" must be understood as departures of experienced faculty net of hires of experienced faculty. We also assume that all of these inexperienced new hires fill non-tenured positions. The data from the 1975 Carnegie Survey show that this assumption is incompatible with equating "year of receiving the doctorate" with "entry into full-time academic employment," a premise we have used in estimating various probabilities in our model. There are a significant number of people who receive tenure within a year of receiving

their degrees. However, their biological ages at tenure are generally the same as faculty who waited more than five years to get tenure. This suggests (but in no way proves) that such "exceptional" people are in faculty positions while working on their doctorates. If there should be a large change in the fraction of faculty doing this, then, for this reason alone, current promotion probabilities and quit rates would not hold in the future. We would still have a Markov process, but the transition probabilities would not be constant over time.

The advantage of a Markovian model is the simplicity it allows for calculating the future distribution of faculty among states (i.e., by age and tenure status). Define the following:

$\mathcal{F}_0$ = the distribution of faculty among states as of time "0" (e.g. 1975)

$E[T(i,j,t)] = E[T(i,j,t) \mid \mathcal{F}_0]$

$E[N(i,j,t)] = E[N(i,j,t) \mid \mathcal{F}_0]$

$a(i,j,t)$ = the probability of staying in academia and not being promoted given $E = j$, $A(t) = i$, $n(t)$ = "non-tenured"

$b(i,j,t)$ = the probability of staying in academia and being promoted to tenure given $E = j$, $A(t) = i$ and $n(t)$ = "non-tenured"

$c(i,j,t)$ = the probability of staying in academia one more year given $E = j$, $A(t) = i$ and $n(t)$ = tenured.

$h(j,t)$ = the probability of hiring someone of age j at time t

$H(t)$ = expected total hires at time t

$D(t)$ = expected total doctorate faculty at time t.

With these definitions and our Markov assumption it is easy to derive the following recursive formulas for the expected number of tenured and non-tenured faculty of each age at every date:

$$E[T(i+1, j, t+1)] = \begin{cases} c(i,j,t)\, E[T(i,j,t)] \\ \quad + b(i,j,t)\, E[N(i,j,t)], \text{ if } i \geq 1, \\ 0 \text{ , if } i = 0 \end{cases}$$

$$E[N(i+1, j, t+1)] = \begin{cases} a(i,j,t)\, E[N(i,j,t)] \text{ , if } i \geq 1, \\ \\ h(j,t)\, H(t+1), \text{ if } i = 0 \end{cases}$$

$$H(t+1) = \max \{0, \tilde{H}(t+1)\}$$

$$\tilde{H}(t+1) = D(t+1) - \sum_{i=2} E[N(i+1, j, t+1)] + E[T(i+1, j, t+1)]$$

$$= D(t+1) - D(t) + \sum_{i=1} \{1 - a(i,j,t) + b(i,j,t)\} \times E[N(i,j,t)]$$

$$+ \sum_{i=1} \{1 - c(i,j,t)\} \times E[T(i,j,t)]$$

Implicitly we have assumed in the above calculations that total faculty size is independent of gross faculty outflow. However, this is at best an approximation since the rate at which the faculty can contract is bounded by the rate of faculty departures. Hence any projection with "negative hirings" displays a contradiction between the assumptions underlying faculty attrition and those determining faculty demand. Our expedient of bounding hires by zero is arbitrary; it would be better to

have "feedback" whereby very low hires would imply higher quit rates (perhaps reflecting falling relative salaries or terminations of non-tenured faculty).

Our rationale for concentrating on the expected value of the number of people in each state are the "laws of large numbers." This theorem claims that the mean of a "large number" of independent, identically distributed random variables has a small variance. In the next section of this appendix we have computed bounds on the variances of many of the statistics of interest--the tenure ratio, the median age of the faculty, and the level of hiring. These bounds are all small, relative to the order of magnitude of the variables.

Expressing the transition probabilities in terms of more basic parameters is our next concern. We propose assuming that death and retirement rates depend only on biological age, which we will call "age," while promotion and quit rates are a function only of academic age, which we will call "experience," and the current date. Retirement rates depend on compulsory provisions--stated almost always in terms of age--and pension incentives for voluntary retirement, which are partly based on "years of service," but most often, after a threshold of experience, depend on salary. Furthermore, as we will see, the age distribution, conditioned on experience, becomes much more compact in the older age groups; i.e., among those eligible for retirement, age and experience are reasonably good proxies for each other. That promotion rates are, to first order, a function of experience alone is suggested by research on promotion by Roy Radner and Charlotte Kuh [1977]. They found experience to be superior to age in explaining "age at tenure." A simple lifetime-income maximization model, designed to predict when

non-tenured faculty will choose to leave academia suggests that experience is, along with relative salaries and rates of promotion, a much more important predictor than age. Finally, since the vast majority (94%) of faculty are tenured by age 60, below which retirements are negligible, at worst we are introducing a small error by assuming that retirement rates are the same for tenured and non-tenured faculty.

Therefore, if we define the following probabilities:

$\delta(k,t)$ = P{dying or retiring at t , given one does not quit academia and B(t) = k}

$\phi(i,t)$ = P{receiving tenure at t , given one does not die or retire and A(t) = i}

$q(i,t;T)$ = P{quitting academia at t , given one is still non-tenured at t+1 and A(t) = i}

$q(i,t;N)$ = P{quitting academia at time t , given one is still non-tenured at t+1 and A(t) = i}

then:

$$a(i,j,t) = [1 - q(i,t;N)]\,[1 - \delta(i+j,t)]\,[1 - \phi(i,t)]$$

$$b(i,j,t) = [1 - q(i,t;T)]\,[1 - \delta(i+j,t)]\,\phi(i,t)$$

$$c(i,j,t) = [1 - q(i,t;T)]\,[1 - \delta(i+j,t)]$$

With people of given experience there is a distribution of ages; define:

$$\alpha(i,j,t) = P\{B(t) = i+j \mid A(t) = i\} = P\{E = j \mid A(t) = i\} \quad .$$

If we assume that the longest anyone ever worked in academia is 40 years and that ages at entry spanned only 10 years (which is true for 80% of doctorate faculty, if one assumes date of entry into full-time academic employment coincides with the date of receiving their Ph.D.), our model would consist of $2 \times 40 \times 10 = 800$ states! Fortunately, with our current assumptions, we can aggregate across ages at entry to obtain a model whose states depend only on experience and tenure status. It is possible to convert at any time from the experience distribution to the age distribution using the matrix of probabilities $[\alpha(i,j,t)]$.

Let X(t) be the event: "not receiving tenure or quitting at t." Simple conditional probability laws give us the identity:

$$P\{E = j | A(t) = i \text{ and } X(t)\} \cdot P\{X(t) | A(t) = i\}$$
$$= P\{X(t) | A(t) = i, E = j\} \cdot P\{E = j | A(t) = i\} \quad .$$

Since we are assuming quitting and promotion to be independent of age at entry, we have the identity:

$$P\{X(t) | A(t) = i , E = j\} = P\{X(t) | A(t) = i\} \quad ;$$

upon cancelling these terms in our first equation we get:

$$P\{E = j | A(t) = i \text{ and } X(t)\} = P\{E = j | A(t) = i\} = \alpha(i,j,t) \quad .$$

The above also holds for X'(t) = "receiving tenure but not quitting at t" and X"(t) = "not quitting at t." Consider now a cohort entering academia in, say, 1960. In 1961 they have all been in academia one year. Whether they are tenured or not depends on receiving or not receiving tenure during 1960. However, we have just found that knowing whether one was tenured or not gives no extra information on the age one had on

entering in 1960. Proceeding recursively, we see that at every date the distribution of age at entry is the same for the tenured and non-tenured members of any cohort (who are still in academia). Hence the distribution for each group is the unconditional distribution: $\{\alpha(i,j,t)\}$. As a result, denoting $E[N(k,\cdot,t)] = \sum_j E[N(i,j,t)]$ and $E[T(i,\cdot,t)] = \sum_j E[T(i,j,t)]$, we have:

$$E[N(i,j,t)] = \alpha(i,j,t)E[N(i,\cdot,t)],$$

$$E[T(i,j,t)] = \alpha(i,j,t)E[T(i,\cdot,t)] \quad .$$

Now, going back to our transition probabilities, letting

$$\Delta(i,t) = \sum_j \alpha(i,j,t)\ \delta(i+j,t),$$

we find that for $i \geq 1$:

$$E[T(i+1,\cdot,t+1)] = [1 - \Delta(i,t)]\ [1 - q(i,t;T)]\ \times$$
$$\{\phi(i,t)\ E[N(i,\cdot,t)] + E[T(i,\cdot,t)]\}$$

$$E[N(i+1,\cdot,t+1)] = [1 - \Delta(i,t)]\ [1 - q(i,t;N)]\ \times$$
$$[1 - \phi(i,t)]\ E[N(i,\cdot,t)] \quad ,$$

while our assumptions on hiring yield:

$$E[T(0,\cdot,t)] \equiv 0$$

$$E[N(0,\cdot,t)] = H(t) = \max\{0, D(t) - \sum_{i\geq 1} E[T(i,\cdot,t) + N(i,\cdot,t)]\} \quad .$$

The same logic we used above yields the conclusion that the evolution of $\{\alpha(i,j,t)\}$ is independent of the time path of quits or promotions, and hence depends only on retirement and death rates. In fact, we can derive the simple recursive formula:

$$\frac{\alpha(i+1,\ j,\ t+1)}{\alpha(i+1,\ k,\ t+1)} = \frac{\alpha(i,j,t)\ [1 - \delta(i+j,t)]}{\alpha(i,k,t)\ [1 - \delta(i+k,t)]}$$

when the denominators are non-zero. Note that if δ is monotone increasing in age, then for $j < k$, $\frac{\alpha(i+1,j,t+1)}{\alpha(i+1,k,t+1)} \geq \frac{\alpha(i,j,t)}{\alpha(i,k,t)}$. This means that the distribution of age at entry, given experience, keeps getting younger. For example, if everyone retires by age 70, then of those who have been in academia 40 years, only people who entered before the age of 30 remain. At any point in time we can convert our expected academic-age distributions to biological-age distributions through the formulas:

$$E[\hat{T}(k,t)] \overset{df}{\equiv} \sum_{i+j=k} E[T(i,j,t)] = \sum_{j \leq k} \alpha(k-j,j,t)\ E[T(k-j,\cdot,t)]$$

$$E[\hat{N}(k,t)] \overset{df}{\equiv} \sum_{i+j=k} E[N(i,j,t)] = \sum_{j \leq k} \alpha(k-j,j,t)\ E[N(k-j,\cdot,t)] \quad .$$

Lacking any data that show it to be shifting, we further assume that the entry age distribution, $\alpha(0,j,t)$, is stationary over our projection period.

Appendix 2:

Variances of the Projected Population Means

Reiterating our comments in the introduction to the main report, although our model of faculty demography is a probabilistic one, we have chosen to use the estimated means as summary statistics for describing the evolution of the tenure ratio, age cohorts and hirings, ignoring the rest of the distribution. Our reason was that for the population size we were considering, the variances of the random variates were so small as to be inconsequential; this is equivalent to claiming very small confidence intervals for our estimates. We now wish to substantiate this claim by calculating variances for the population variables we listed above. We will also explore the dependence of these variances on the population size, examining how appropriate our method would be for smaller populations.

To see how we can go about this, let us first suppose that the number of faculty stays constant over the projection horizon. Hence with every individual who leaves academia at any age there is a person hired. We saw in the last section that under certain assumptions it is possible to work with knowledge only of the academic age of each individual. As a result, by definition, entry "age" is always age 1. (Hence hires of experienced faculty are implicitly accounted for in our net quit rates.) Such a model, positing a continuous "recirculation" of individuals who leave at random ages, is important in Markov theory, and is known as a recurrent process (Kemeny and Snell, [1960]). By keeping the fiction of having each person who leaves re-enter academic employment at the bottom of the ladder, we can assign to every individual an "age" at every date-- even after they leave academia-- by assigning the age of their replacement.

Let $P(j,i)$ be the probability of being of age j in 1995 given that one is of age i in 1975, and for every person, k,

$$\text{let } x(i,k) = \begin{cases} 1 & \text{if } k \text{ is of age } i \text{ in 1995} \\ 0 & \text{otherwise} \end{cases}$$

and

$$x^{\circ}(i,k) = \begin{cases} 1 & \text{if } k \text{ is of age } i \text{ in 1975} \\ 0 & \text{otherwise} \end{cases}$$

Then we have:

$$E[x(j,k) \mid x^{\circ}(i,k)] = \sum_i P(j,i)\, x^{\circ}(i,k)$$

$$\text{Var}[x(j,k) \mid x^{\circ}(i,k)] = \sum_i P(j,i)[1-P(j,i)]\, x^{\circ}(i,k)$$

Because the "aging" of each person is viewed as independent from all others, for the population sums,

$$\bar{x}(i) = \sum_k x(i,k)$$

and $$\bar{x}^{\circ}(i) = \sum_k x^{\circ}(i,k) \quad ,$$

we have:

$$E[\bar{x}(j) \mid \bar{x}^{\circ}(1), \cdots, \bar{x}^{\circ}(45)] = \sum_i P(j,i)\, \bar{x}^{\circ}(i)$$

$$\text{Var}[\bar{x}(j) \mid \bar{x}^{\circ}(1), \cdots, \bar{x}^{\circ}(45)] = \sum_i P(j,i)[1-P(j,i)]\, \bar{x}^{\circ}(i) \quad .$$

Although we have aggregated over tenured and non-tenured faculty in the above, if we reinterpret the index "i" as a vector consisting of age and tenure status, we see that the formulas quickly generalize. We can also generalize to allow for contraction and expansion of total faculty size by conditioning on the year one entered academia and summing over these different sub-groups. Hence if $P^t(i)$ is the probability of being of age i in 1995 given one entered academic employment in year t, and $\Delta D(t)$ is the (exogenous) change in total faculty in year 1975 + t, then:

$$E[\bar{x}(j) \mid \bar{x}^\circ(1), \cdots, \Delta D(1), \cdots, \Delta D(20)] =$$

$$\sum_i P(j,i)\bar{x}^\circ(i) + \sum_t P^t(j)\,\Delta D(t)$$

$$Var[\bar{x}(j) \mid \bar{x}^\circ(1) \cdots, \Delta D(20)] =$$

$$\sum_i P(j,i)[1-P(j,i)]\bar{x}^\circ(i) + \sum_t P^t(j)[1-P^t(j)] \times |\Delta D(t)| \quad .$$

The drawback with this approach is the magnitude of the calculations required to determine $P^t(i)$ and $P(i,j)$. However, we can obtain a crude bound for the variance and coefficient of variation of the fraction of those at age i in 1995 which is independent of these probabilities. Letting $f(i) = \bar{x}(i) / \sum_i \bar{x}(i)$,

$N = \sum \bar{x}(i)$ and $N^\circ = \sum \bar{x}^\circ(i)$, we have:

$$Var[f(i) \mid \bar{x}^\circ(1), \cdots, \Delta D(20)] \leq \frac{1}{4} \frac{N^\circ + \sum_t |\Delta D(t)|}{N^2} \equiv B \quad .$$

Furthermore, as the biological age distribution, g(i), is the weighted sum, $\sum_j \alpha(i,j)f(j)$ ($\sum_j \alpha(i,j) \equiv 1$), and the $\bar{x}(i)$ are negatively correlated, we see that the bound applies to the variance of g(i) also.

Table A0

Bounds on variance of the $\bar{x}(i)$ assuming different projections of faculty demand in 1995

Demand projection	N^1	$\sum_t \lvert\Delta D(t)\rvert^1$	B
Pro-cyclical	161,784	47,613	2.8×10^{-6}
No Change	200,496	44,434	1.4×10^{-6}
Counter-cyclical	239,208	61,353	1.1×10^{-6}

[1]Source: Table 1 - 5.

For the ages greater than 20, this bound is a gross over-estimate, since if i ≥ 20, the person must have been in academia in 1975, hence:

$$E[\bar{x}(i) \mid \bar{x}^\circ(1), \cdots, \Delta D(20)] = P(i, i-19)\, \bar{x}^\circ(i-19),$$

and

$$\begin{aligned} \mathrm{Var}[f(i) \mid \bar{x}^\circ(1), \cdots, \Delta D(20)] &\leq \frac{1}{4} \frac{\bar{x}^\circ(i-19)}{N^\circ} \frac{1}{N} \\ &\leq 3.09 \times 10^{-6} \frac{\bar{x}^\circ(i-19)}{N^\circ} . \end{aligned}$$

With these two sets of bounds we have below calculated the average coefficient of variation (the standard deviation divided by the mean, denoted C.V.) of the 1995 age distribution, by five-year age groups. The $\bar{x}(i)$ used are from the baseline projection (See Table 2-16).

Table A1

Bounds on the Coefficient of Variation

Tenured faculty			Non-tenured faculty		
Biological age	$\bar{x}(i)$	C.V.	Biological age	$\bar{x}(i)$	C.V.
25-30	.004	.418	25-30	.325	.025
31-35	.035	.047	31-35	.384	.021
36-40	.056	.030	36-40	.157	.053
41-45	.117	.014	41-45	.079	.105
46-50	.156	.005	46-50	.029	.012
51-55	.210	.002	51-55	.014	.038
56-60	.218	.001	56-60	.007	.058
61-65	.176	.001	61-65	.004	.064
66-70	.026	.013	66-70	.003	.069

The crudeness of these bounds needs to be emphasized; the "true" coefficients of variation are in most cases at least an order of magnitude lower than these numbers.

Bounds on the variance of the tenure ratio and the level of new hires are quite simple. Let T(i) be the number of tenured faculty i years old in 1995 and let $t = \sum_i T(i)/N$ be the fraction of total faculty with tenure. Then:

$$\mathrm{Var}[t \mid \bar{x}^{\circ}(1), \cdots, \Delta D(20)] \leq \sum_i \mathrm{Var}\left(\frac{T(i)}{N}\right) \leq 45 \times B = 1.26 \times 10^{-4}$$

The first inequality follows from the negative covariance of the T(i). Hence the standard deviation is bounded by 0.011, whereas the lowest tenure ratio projected for 1995 is 0.68. Of course, new hires in 1995 are $\bar{x}(1)$. The standard deviation of $\bar{x}(1)/N$ is bounded by $\sqrt{B}$ = .0016, giving a bound on the coefficient of variation for $\bar{x}(1)$ (assuming the baseline projection of 8370 hires) of .038. However, the coefficient of variation of $\bar{x}(1)$ and $\bar{x}(1)/N$ are the same (conditional on N, of course). Hence 8370 $\pm$ 630 people is a 95% confidence interval for new hires in 1995, under the assumptions of the baseline projection.

Our interest in the age distribution stems from concern over the quality of teaching faculty, and the belief that this quality deteriorates with age. If the deterioration in teaching effectiveness and research output were approximately linear in age, then the mean of the age distribution would be a useful summary statistic of the age distribution. However, research on the issue (Lehman [1953]) casts doubt on this, showing instead at least one and often two peaks in activity and output as faculty age. Hence the median age of the faculty provides a better measure of "vitality" than the mean, which is one reason we have used it as a statistic. It also has a nice property of being little affected by the probabilities attached to the extreme ages--precisely the ages where the future age distribution has the largest stochastic component.

Our recorded ages take integral values; hence our age distribution must be discreet. The median in this case is usually defined, for a frequency function p(i), by the equation:

$$\sum_{i=1}^{m^*-1} p(i) < \frac{1}{2} \leq \sum_{i=1}^{m^*} p(i) \quad .$$

Such a definition, however, ignores the "gap" between $\sum_{1}^{m^*-1} p(i)$ and $\sum_{1}^{m^*} p(i)$, thereby throwing away useful information. Hence we have defined the median as:

$$\tilde{m} = (m^*-1) + \frac{\sum_{1}^{m^*-1} p(i) - \frac{1}{2}}{p(m^*)} \quad .$$

This is the median of the sum of the integral-valued random variable with frequency function $p(i)$ and a random variable uniformly distributed on $[0,1]$. If in a sample of size N we observe $\bar{x}(i)$ people of age i, then a reasonable estimate of $\tilde{m}$ is :

$$M = (\hat{m} - 1) + \frac{\sum_{1}^{\hat{m}-1} \bar{x}(i) - N/2}{\bar{x}(\hat{m})}$$

where $\sum_{1}^{\hat{m}-1} \bar{x}(i) < \frac{N}{2} \leq \sum_{1}^{\hat{m}} \bar{x}(i)$.

Through the probability theory of order-statistics (See Kendall and Stuart [1969], Vol. 1, Chapter 14), it can be shown that for large sample sizes M converges in probability to $\tilde{m}$ and that its approximate mean squared error is $(4N\ p(m^*)^2)^{-1}$. This derivation, incidentally, requires that $m^* \neq \tilde{m}$. Among our projections, for tenured faculty $p(m^*)$ is always greater than .04, and the median age varies from 48 to 56; for non-tenured faculty $p(m^*) \geq .08$, while the median age is always between 34 and 37. Hence we have the following bounds on the mean squared error and coefficient of variation of these two median ages.

Table A2

Approximate Bounds for Population Sizes over 200,000

Median ages of:	Variance	Coefficient of variation
Tenured faculty	3.1×10^{-5}	1.2×10^{-4}
Non-tenured faculty	1.5×10^{-5}	1.2×10^{-4}

These variances are remarkably small numbers, suggesting how poor are the bounds on the standard deviation of the hiring level and the tenure ratio calculated above.

In summary, we have recalculated our bounds on the coefficient of variation for different sample sizes and presented them below.

Table A3

Variate	"Baseline" 1995 projection	Bounds on the Coefficient of Variation of the Variates Population sizes		
		187,000	10,000	1,000
Tenure ratio	.840	.013	.059	.188
Hiring rate	4.36%	.038	.171	.544
Median age:				
Tenured faculty	56.2	1.0×10^{-4}	4.46×10^{-4}	1.4×10^{-3}
Non-tenured faculty	35.0	1.1×10^{-4}	4.9×10^{-4}	1.5×10^{-3}

Sources: Table 2-20 and author's calculations.

"Population size" in the table refers to its size in 1975; we assume that, thereafter, the transition probabilities are the same as those of the baseline projection. As a result, the bounds on the C.V. are proportional to the inverse of the square root of the 1975 population size.

Appendix 3:
Estimation of the Model's Parameters

The model we have constructed has four sets of parameters: the probabilities of dying, retiring, receiving tenure, or quitting; the level of employed doctorate faculty; the cohort sizes and tenure ratio in 1975; and the age distribution of new hires. We have just seen that the forecasting error of our projections lies almost entirely with error in predicting the evolution of the parameters or with a poor modeling. For example, there is no reason to believe that our aggregating over the diverse array of types of institutions--each with different growth patterns, age distributions of faculty, mixtures of research and teaching faculty, links with non-academic employers, concepts about tenure, preferences for new doctorate faculty versus experienced non-doctorate faculty, etc.--introduces only "second-order" error. We will not discuss the appropriateness of our model further, but will instead focus our attention on the way we have estimated its basic parameters. Once we are confident that we have done as careful and accurate a job of inferring the likely consequences of a world operating as we have posited it, we can go on to the more formidable task of criticizing and amending our simplifications of reality.

I. Death and retirement rates

Since most doctorate faculty are white males (88.2% according to the 1975 Carnegie Survey), we have chosen to use the death rates for white males (See U.S. Public Health Service [1970], Table I-8). Accounting for the lower death rates of women--which are as much as 50% lower up to age 70-- would have lowered our death rates for 1975 by at most 5% projecting the death rates would require projecting the sex ratio, a difficult task at the moment. Furthermore, our death rates--

which are aggregated over all economic classes--are likely to be higher than that suffered by doctorate faculty, a group which is far from representative of the society. This latter error is, in all likelihood, much greater than that due to ignoring the lower mortality of women. Lacking data more representative of our population, we decided not to try to "adjust" what we had.

The Census Bureau reports these rates by five-year age groups rather than by individual ages. Although demographers have elaborate methods to infer the age-specific rates from these "group" rates, the problems in our data did not seem to warrant such precision (See Keyfitz [1977], p. 38). Hence we proceeded by: (1) assigning the group death rate to each age in a group, and (2) then "smoothing" this series by finding the best fit to a fourth-degree polynomial.

The same problem that plagues us with regard to death rates--inadequate data--arises in determining the current age-specific retirement rates of doctorate faculty. Currently, there are two surveys of academic retirees that can be used (albeit feebly) to infer current retirement rates. The first is a survey of retirees at twelve colleges conducted by King [1970] under the auspices of the Teachers Insurance and Annuitants Association (TIAA). Although he has calculated the age distribution of retirees by year of retirement, the smallness of his sample of schools casts doubts on its representativeness; colleges could be expected to have high variability in retirement rates over time as well as cross-sectionally. We were happy, then, to find that in 1973 the TIAA conducted a similar survey of its annuitants (Ingraham [1974]). Though this survey omits the large number of retirees who are not on TIAA pension plans (hence excluding

all retired faculty from the University of California, for example), it has a wide enough scope to allow us to construct "ball-park" estimates.

Our task is now the following: infer the age distribution of retirees for the period covered by the TIAA survey, extrapolate them to 1975, then determine (if possible) the implied age-specific retirement rates in that year.

The first is already troublesome, since the age at retirement has been tabulated only against the age of the respondent in 1973. Because of the evidence of a downward shift in the age at retirement over this period (King [1970], Mulanaphy [1974], Patton [1977]) the distribution of retirement age obtained from the survey is higher than the (unknown) distribution of ages among those who retired in 1973; assuming this trend continued, the 1975 ages at retirement were, on average, lower still. A countervailing tendency--and probably more serious--is the bias toward observing the "young" retirees; since the older ex-faculty are so much more likely to have died before being surveyed. For example, of those who retired in 1965, someone who was 60 years old had a 78% chance of surviving until 1972-73, while someone who was 65 had only a 65% chance of living until 1972; this is a difference of 17%. However, in a study of University of California employees, many of the "early retirees" left for medical reasons; hence conditional on age of retirement, the life expectancy of faculty could be very different from the unconditional life expectancy we employed above (Patton [1977]). Considering our extensive ignorance, trying to "correct" our data for mortality could create inaccuracies rather than removing them. Below are the data obtained from the TIAA survey. We have chosen to use as our estimate of the age distribution of retirees

in 1975 the series for academic employees, which is based on a sample of 1171 respondents, even though the sample includes people who retired before 1960.

Table A4

Age at Retirement

1972-73 TIAA Survey of Annuitants

Age at retirement	All Respondents	Age 60-70	Age 71-77	Age over 78	Working Academic	Career Non-academic
Total Respondents	1507	732	519	256	1192	219
No Response	36	14	14	8	21	8
under 60	7.1	10.1	3.9	5.1	7.0	5.0
60	1.8	2.5	1.2	1.2	1.5	3.2
61	1.9	2.7	1.0	1.2	1.7	3.2
62	4.4	8.3	1.0	.4	4.2	6.4
63	3.5	6.0	1.0	1.2	2.9	5.0
64	3.9	6.0	2.5	.8	2.9	8.2
65	24.3	30.0	18.4	19.9	23.1	30.6
66	14.8	16.3	15.0	10.2	15.6	11.4
67	7.1	6.6	7.5	7.8	7.2	6.4
68	9.0	5.9	12.5	10.9	10.4	2.7
69	6.0	2.7	10.4	6.3	6.5	4.1
70	6.4	1.0	11.9	10.5	7.0	4.1
over 70	7.4	0	11.0	21.4	7.2	6.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Specially tabulated for the author by Dr. Peggy Heim at the TIAA.

There are two methods of infering retirement rates from the age distribution of retirement, both requiring unverified assumptions. The first relationship is the following: let

$p(i,t)$ = the fraction of those of age i at t who retire,

$r(i,t)$ = the fraction of those who retire at date t who are of age i,

$n(i,t)$ = the fraction of those who <u>don't</u> retire at date t who are of age i,

$$R(t) = \frac{\text{total retirees at time t}}{\text{total non-retirees at time t}},$$

then, tautologically:

$$\frac{R(t)\, r(i,t)}{N(t)\, n(i,t)} = \frac{p(i,t)}{1-p(i,t)} \quad .$$

Cartter (1976), using Office of Education data as well as the 1973 A.C.E. survey of faculty, estimated R(1970) to be .0094 and projected R(1980) to be .0065. Linear interpolation gives us an estimate of R(1974) of .0084. The Carnegie faculty survey conducted in 1975 sampled from the 1974 non-retirees. If we denote by F(i) the estimated age distribution of faculty in 1975 obtained from the survey, then $F(i+1) = \hat{n}(i,1974)$. By making the (crucial) assumption that $r(i,1960\text{-}1972) = r(i,1974)$, the TIAA survey data give us an estimate of r(i, 1974), which we will denote $\hat{r}(i, 1974)$. We can now use the tautology above to estimate p(i,1974):

$$\frac{\hat{p}(i,1974)}{1-\hat{p}(i,1974)} = 0.0084 \quad \frac{\hat{r}(i,1974)}{F(i+1)}$$

Since $\hat{r}(i,1960\text{-}1972)$ and $F(i+1)$ are based on samples, they have sampling variances $\nu(i)$ and $\omega(i)$, respectively, which we can estimate by:

$$\hat{\nu}(i) = F(i+1)[1-F(i+1)]/9010$$

$$\hat{\omega}(i) = \hat{r}(i,1960\text{-}72)[1-\hat{r}(i,1960\text{-}72)]/1171,$$

where 9010 and 1171 are the sample sizes.

By using a Taylor expansion on our estimating equation for $\hat{p}(i)$, we obtain the following estimate of the variance of $p(i,1974) \equiv \hat{p}(i)$:

$$\hat{\text{Var}}\ p(i) \simeq \hat{p}(i)^2\,[1-\hat{p}(i)]^2 \left\{ \frac{\hat{\omega}(i)}{\hat{r}(i,1960\text{-}72)^2} + \frac{\hat{\nu}(i)}{F(i+1)^2} \right\}$$

Below we have listed our data and estimates of $\hat{p}(i)$ and Var $\hat{p}(i)$ for ages 65 to 69. As can be seen the sampling error is very low (hence enhancing the accuracy of the approximation we employed for the variance of $\hat{p}(i)$); if we did not suspect so many sources of biasing our data had no qualms about the two assumptions we had to make, these estimates of the p(i) would be very reliable.

Table A5

First Estimates of Age-Specific Retirement Rates

Age	$\hat{r}(i,1960\text{-}72)$	$F(i+1)$	$\hat{p}(i)$	Standard error of p(i)
65	.231	.004	.326	.038
66	.156	.003	.304	.042
67	.072	.002	.232	.043
68	.104	.001	.466	.083
69	.065	.001	.353	.077

Sources: Table A4 and 1975 Carnegie Survey of U.S. Faculty, calculated from raw data tape.

A second approach that does not require knowledge of r(i,t) but needs an assumption about the age distribution of non-retirees employs the tautology (using our notation above);

$$\frac{n(i-1,t-1)[1-p(i,t)]}{n(j-1,t-1)[1-p(j,t)]} = \frac{n(i,t)}{n(j,t)} ,$$

since all non-retirees at time t must have been non-retirees at t-1. If we can assume $\frac{n(i,t-1)}{n(j,t-1)} = \frac{n(i,t)}{n(j,t)}$ for $i,j \geq 64$--which is equivalent to assuming that the age distribution, conditional on being over 64, is in a steady state--then for $i \geq 65$ we have:

$$1 - \hat{p}(i,1974) = \frac{F(i+1)\ F(64)\ (1-\hat{r}(64,1974))}{F(i)\ \ F(65)} \quad \text{and}$$

$$\frac{\hat{Var}\ \hat{p}(i,1974)}{1 - \hat{p}(i,1974)} \simeq \frac{v(i+1)}{F(i+1)^2} + \frac{v(64)}{F(64)^2} + \frac{v(i)}{F(i)^2} + \frac{v(65)}{F(65)^2} .$$

Table A6

Second Estimates of Age-Specific Retirement Rates

Age	F(i+1)/F(i)	$\hat{p}(i,1974)$ r(64)=.20	$\hat{p}(i,1974)$ r(64)=0	Std. Error of $\frac{\hat{p}(i)}{1-\hat{p}(i,1974)}$
65	.57	.48	.35	.34
66	.75	.31	.13	.38
67	.67	.39	.23	.47
68	.50	.66	.42	.52
69	1.00	.09	--*	.52

*The estimate was negative.

Having no estimate of r(64,1974), we have to condition our estimates on its value. Believing 20% to be a likely upper bound on r(64,1974), $\hat{r}$(i,1974) has been computed for this value as well as zero. The standard errors reported are biased down, but are now much larger than for our first estimates. This is compensated by the likely reduction in bias, since our data are more representative of all doctorate faculty; however, anomalies such as the estimate for p(69) of .09 suggest some unreliability. This lack of consistency could be due either to sampling error or to the inappropriateness of the various identifying restrictions we have employed.

Fortunately, we have data on retirement rates resulting from a survey of U.S. colleges conducted by Greenough and King in 1967 (Greenough and King [1969]). In that survey, institutions (in contrast to faculty) were asked what their "normal retirement age" was as well as whether they required all faculty to retire at this normal age. With identifying assumptions, these data are adequate for estimating the retirement rates at four-year institutions in 1968.

Mulanaphy (Mulanaphy [1974]) reports survey results showing very few faculty retiring before the mandatory age at their institution. Hence, as a simplification, we have assumed that no faculty retire "early," i.e., before the normal retirement age at their respective colleges. As a result, at schools where the "normal" age of retirement is also a mandatory age, we assume that all faculty retire exactly at this age. If this were the case at every school, then knowing the distribution of faculty among schools with different ages of mandatory retirement would give us an estimate of the fraction of faculty retiring in 1968 at any

given age i; call this fraction r(i). If the fraction of faculty of age i in 1968 is p(i) and the fraction of faculty retiring is R, then R r(i)/p(i) is the fraction of people of age i who retired in 1968. Estimates of each of these three variables are sufficient for estimating the age-specific rates of retirement in 1968.

Unfortunately, over half of four-year institutions did not have mandatory retirement ages in 1968. At these "flexible age" schools some faculty were given "extentions" allowing them to continue working beyond the normal age for retiring. King [1970], examining the retirement policies of 12 liberal arts colleges, found that approximately half of the faculty were given extentions for one year past the "normal age"; of these people, 70% had their extentions renewed in each subsequent year. Although his sample is surely not representative, for lack of better figures, we will assume that this is the pattern in all of academia. This pattern implies, for example, that at a flexible age college whose normal retirement age is 65: 50% of its facutly retire at 65, 15% retire at 66, 10.5% retire at 67, 7.4% retire at 68, 5% retire at 69 and 12% retire at 70 or after. We can now use the Greenough and King data to estimate r(i) and the age-specific retirement rates prevailing in academia in 1968. We will call these our GK-rates.

Table A7 lists the GK-rates. They are characterized by "spikes" at ages 65 and 70 due to the large number of faculty forced to retire at these two ages. These rates imply that about 10% of faculty retire before the age 65 and about 20% retire at age 70. Table A8 compares our estimated age-specific rates of retiring or dying with the series used by Cartter in his projections. Although our age-specific rates are higher, our younger age distribution gives us a lower mean rate.

Table A7

BASELINE RETIREMENT RATES

AGE	*GK-RATES*
≤59	0.00
60	0.01
61	0.02
62	0.02
63	0.02
64	0.02
65	0.29
66	0.18
67	0.18
68	0.20
69	0.12
70	1.00
>70	0.00

SOURCE: GREENOUGH AND KING [1969], *P. 52 AND COMPUTATIONS OF THE AUTHOR.*

Table A8

Retirement and Death Rates by Age Groups

Academic Age-Specific		Biological Age-Specific		
Ages	Fernandez	Ages	Fernandez	Cartter
1- 5	.002	26-30	.001	.002
6-10	.003	31-35	.002	.002
11-15	.004	36-40	.003	.003
16-20	.006	41-45	.004	.004
21-25	.011	46-50	.007	.007
26-30	.020	51-55	.012	.011
31-35	.076	56-60	.020	.017
36-40	.273	61-65	.116	.066
41-45	.619	66-70	.537	.337
Mean Value:	.014		.014	.016

Source: Author's calculations and Cartter [1976], Table 8-11.

II. Promotion rates

In Section 2 of the report we stated our assumption that the probability of receiving tenure was a simple function of the date and the number of years one has been working at academic institutions. Defining $\Phi(i,t)$ =

P { receiving tenure during year t | one is t years old and non-tenured at t },

we had:

$$\ln \frac{\Phi(i,t)}{1-\Phi(i,t)} = \alpha(i) + \beta(t) \quad .$$

$\alpha(i)$ we call the "age effect" and $\beta(t)$ the "date effect." The age effect reflects in part the probability of being under tenure review (which is usually after some probationary period of 3 to 6 years), while the date effect measures in part the impact of changing demand for experienced faculty on promotions. However, the interpretations are muddied by the fact that when faculty are in high demand, tenure reviews can be expected to come up earlier (in order to counter outside offers), while in a glutted market, departments can put off tenure decisions for a long time.

Radner and Kuh [1977], using data from the 1975 Carnegie Council survey of U.S. faculty, estimated the age and date effects of the promotion rates of full-time doctorate faculty. Their results are marred by two problems with their data. First, since the survey's sampling universe consisted of faculty <u>still</u> in academia in 1975, higher quit rates among non-tenured faculty (for example) would lead one to infer faster promotion rates than was the case over the period studied. Second, the survey did not ask the respondents how long they has been teaching and doing research at colleges and universities; hence we chose to assume that all faculty received their first "real" academic job upon receiving their doctorate, since the date of receipt of the Ph.D. was asked of them. Yet an examination of the ages of those who received tenure less than three years after receiving their doctorates showed them to be suspiciously old at the time, suggesting that they had been in academia for a while. If this is true, then once again the survey data lead us to believe people receive tenure, on average, earlier than is the case.

As the academic labor market is somewhat segmented by academic field and type of institution, one would expect some consistent differences in

promotion probabilities, controlling for these two characteristics. As a result, letting I denote the type of institution where one is employed and letting

$$\phi(i,t,k) = \{P \{\text{tenured before } t+1 \mid i(a,t) = i \text{ and } I = k\},$$

then:

$$\phi(i,t) = \sum_k \phi(i,t,k) P\{I = k\} .$$

Suppose $\phi(i,t,k) = \frac{A(i,k)B(t,k)}{1 + A(i,k)B(t,k)}$, which is algebraically equivalent to the logit specification above, and define: $\bar{A}(i) = \sum_k A(i,k)P\{I = k\}$, $\bar{B}(t) = \sum_k B(t,k)P\{I = k\}$. A Taylor expansion of $\phi(i,t,k)$ provides the following second-order approximation:

$$\tilde{\phi}(i,t) \simeq \frac{\bar{A}(i)\bar{B}(t)}{1 + \bar{A}(i)\bar{B}(t)} .$$

Using Radner and Kuh's estimates of the age effects for public and private universities and public and private four-year colleges, and assuming the same date effects among the four types of institutions, we have calculated both the exact $\phi(i,t)$ and our approximation $\tilde{\phi}(i,t)$. Since, for a fixed date effect, $\phi(i,t,k)$ is a convex function of the age effect, $\tilde{\phi}(i,t) > \phi(i,t)$ always. However, until academic age 20 the error is less than 2%. Table A9 shows the probabilities for two different values of the date effects. The erratic values of the promotion probabilities are the result of the sampling error in the estimates of our age effects. The third and sixth columns of Table A8 show the promotion probabilities

Table A9

PROMOTION PROBABILITY APPROXIMATIONS

	B=1.0			B=1.45		
AGES	*EXACT VALUE*	*USING MEAN A*	*USING SMOOTH A*	*EXACT VALUE*	*USING MEAN A*	*USING SMOOTH A*
1	0.031	0.032	0.000	0.043	0.044	0.000
2	0.043	0.043	0.069	0.060	0.060	0.098
3	0.088	0.089	0.118	0.119	0.120	0.163
4	0.137	0.139	0.151	0.182	0.184	0.206
5	0.173	0.174	0.173	0.226	0.228	0.234
6	0.218	0.218	0.187	0.280	0.281	0.252
7	0.206	0.207	0.195	0.267	0.268	0.262
8	0.213	0.214	0.199	0.274	0.276	0.266
9	0.188	0.188	0.199	0.245	0.245	0.266
10	0.199	0.200	0.196	0.259	0.259	0.262
11	0.194	0.195	0.192	0.252	0.253	0.257
12	0.166	0.167	0.186	0.217	0.219	0.250
13	0.141	0.141	0.179	0.186	0.187	0.241
14	0.169	0.170	0.172	0.222	0.223	0.232
15	0.164	0.166	0.165	0.215	0.218	0.223
16	0.158	0.159	0.158	0.207	0.210	0.215
17	0.210	0.212	0.152	0.271	0.274	0.207
18	0.140	0.142	0.146	0.185	0.188	0.199
19	0.130	0.131	0.141	0.172	0.175	0.193
20	0.127	0.130	0.137	0.169	0.173	0.188
21	0.123	0.129	0.133	0.162	0.172	0.183
22	0.119	0.120	0.131	0.158	0.160	0.180
23	0.132	0.134	0.129	0.175	0.178	0.177
24	0.050	0.055	0.127	0.066	0.075	0.175
25	0.132	0.137	0.126	0.173	0.182	0.173
26	0.167	0.170	0.124	0.218	0.223	0.172
27	0.041	0.045	0.123	0.054	0.062	0.170
28	0.100	0.128	0.121	0.125	0.170	0.167
29	0.222	0.246	0.119	0.280	0.313	0.165
30	0.119	0.127	0.116	0.156	0.169	0.161
31	0.054	0.056	0.112	0.073	0.076	0.155
32	0.113	0.135	0.107	0.143	0.179	0.149
33	0.025	0.028	0.101	0.033	0.038	0.141
34	0.079	0.109	0.094	0.097	0.146	0.131
35	0.098	0.105	0.085	0.129	0.141	0.120
36	0.000	0.000	0.076	0.000	0.000	0.107
37	0.000	0.000	0.065	0.000	0.000	0.092
38	0.000	0.000	0.054	0.000	0.000	0.076
39	0.124	0.218	0.042	0.142	0.281	0.060
40	0.000	0.000	0.030	0.000	0.000	0.044
41	0.000	0.000	0.020	0.000	0.000	0.028
42	0.000	0.000	0.011	0.000	0.000	0.016
43	0.000	0.000	0.005	0.000	0.000	0.007
			0.004			0.005

obtained by replacing the $\{\bar{A}(i)\}$ with their best least-squares approximation by a fifth-degree polynomial, which we will denote: $\hat{A}(i)$. Our promotion probabilities are then: $\phi(i,t) = \frac{\hat{A}(i)B(t)}{1 + \hat{A}(i)B(t)}$. The discussion of the method of projecting the date effects is found in Section of this report. The second column of Table A10 shows the promotion rates--averaged over age groups--using the estimated 1974 date effect of 1.4. In the fourth column we have converted to promotion rates by biological age, while in the fifth we give the promotion probabilities estimated by Cartter for all faculty in 1973, adjusted so that the mean rate of promotion is the same for the three series. Cartter's promotion rates are much higher--although the median (biological) age of those promoted is 4.9 years older than in our model.

Table A10

RATES OF PROMOTION TO TENURE BY AGE GROUPS

ACADEMIC AGES	*AGE-SPECIFIC FERNANDEZ*	*BIOLOGICAL AGES*	*AGE-SPECIFIC FERNANDEZ*	*AGE-SPECIFIC CARTTER*
1- 5	0.017	26-30	0.005	0.004
6-10	0.031	31-35	0.021	0.013
11-15	0.028	36-40	0.029	0.031
16-20	0.024	41-45	0.027	0.044
21-25	0.021	46-50	0.023	0.045
26-30	0.020	51-55	0.019	0.042
31-35	0.016	56-60	0.021	0.045
36-40	0.009	61-65	0.017	0.029
41-45	0.001	66-70	0.005	0.000

MEAN VALUE: 0.118

SOURCE: *AUTHOR'S CALCULATIONS AND CARTTER* [1976], *TABLE* 8-11.

III. Quit rates

Quitting academia is a serious career decision, reflecting expectations as to one's promotion probabilities and the relative salaries of non-academic employment. A simple model of "optimal" quitting based on lifetime income maximization suggests that $P\{\text{not quitting at } t | i(a;t) = i\} \simeq a(i)b(t)$; for $a(i) \simeq 1$, we have the approximation: $P\{\text{quitting at } t | i(a;t) = i\} \simeq a(i)[1 - b(t)]$. For small probabilities, this formula is also approximately the same as the logit model we assumed for our promotion probabilities. Primarily because of the robustness of the logit model for studying discrete phenomena such as this, rather than any confidence that faculty behave like income maximizers, we have chosen this specification for our probabilities. The main drawback is the assumption that when quit rates change, they do so proportionately. In the case of tenured faculty, this may be approximately true, since quitting is voluntary. However, in the case of non-tenured faculty observed "quits" could have a large "involuntary" component to them. In particular, in the move from a strong academic labor market to one with very few vacant positions, one could observe not only more non-tenured quitting, but observe higher rates at earlier ages, as young faculty who fail to get tenure at their first institution are replaced by newly graduated doctorates, and find no other positions available. The key determinant is the competition between inexperienced and experienced faculty for newly vacated positions, an area which has yet to be explored. With this limitation in mind, we now proceed to obtain estimates of a(i) and b(t) from past observations.

Although Cartter's population includes those without doctorates, he provides us with the only known data on quit rates that distinguishe

faculty by whether or not they are tenured. In his Table 8-11 Cartter gives an estimate of the age distribution of those leaving academia in 1973 for reasons other than death or retirement, which we will denote by q(i). A simple probability identity gives:

$$P_t \{\text{quitting} \mid \text{one's age is i}\} \times P_t \{\text{one's age is i}\}$$

$$= P_t \{\text{one's age is i} \mid \text{quitting}\} \times P_t \{\text{quitting}\}$$

or $[1 - b(t)]\, a(i)\, P_t \{\text{one's age is i}\} = q(i) \times P_t \{\text{quitting}\}$,

or $a(i)$ is proportional to $\dfrac{q(i)}{P_t \{\text{one's age is i}\}}$,

where P_t means: the probability at time t.

Since we assume that it is "academic age" that determines the probability of quitting, while Cartter works with biological age, we first convert his series q(i) to one based on academic age, employing our estimated bivariate distribution of age and experience (discussed below). Let us refer to this new series as $\tilde{q}(i)$. By assuming that the age distribution of quits was the same in both 1973 and 1975, for both tenured and non-tenured faculty, we can then proceed to estimate a(i) by $\tilde{q}(i)/P_{1975}\{\text{one's age is i}\}$, working with tenured and non-tenured faculty separately.

The first columns of Tables A11 and A12 show the resulting quit rates, by academic age, for tenured and non-tenured faculty, respectively. The quit rates have been normalized so that the mean tenured quit rate is

0.5%, while the mean non-tenured quit rate is 2%. The fourth column shows the quit rates conditioned on biological age, allowing us to compare them with the quit rates Cartter estimated. We have normalized the two series so that--for their respective populations, doctorate faculty at four-year institutions and all faculty at all institutions--the mean quit rate is the same. The patterns in the two series are similar, the main difference being that our quit rates are uniformly smaller than Cartter's. This reflects mainly that doctorate faculty are in general younger than the faculty as a whole, and quitting is most likely in the early age cohorts.

Table A11

TENURED FACULTY QUIT RATES BY AGE GROUPS

ACADEMIC AGE-SPECIFIC		*BIOLOGICAL AGE-SPECIFIC*		
AGES	*FERNANDEZ*	*AGES*	*FERNANDEZ*	*CARTTER*
1- 5	0.009	26-30	0.009	0.011
6-10	0.008	31-35	0.008	0.010
11-15	0.006	36-40	0.007	0.008
16-20	0.004	41-45	0.005	0.007
21-25	0.002	46-50	0.003	0.003
26-30	0.002	51-55	0.002	0.002
31-35	0.002	56-60	0.001	0.001
36-40	0.002	61-65	0.002	0.003
41-45	0.003	66-70	0.002	0.002

MEAN VALUE: 0.005

SOURCE: *AUTHOR'S CALCULATIONS AND CARTTER* [1976], *TABLE* 8-11.

Table A12

UNTENURED FACULTY QUIT RATES BY AGE GROUPS

ACADEMIC AGE-SPECIFIC		*BIOLOGICAL AGE-SPECIFIC*		
AGES	*FERNANDEZ*	*AGES*	*FERNANDEZ*	*CARTTER*
1- 5	0.021	26-30	0.024	0.029
6-10	0.019	31-35	0.029	0.019
11-15	0.018	36-40	0.028	0.023
16-20	0.017	41-45	0.027	0.023
21-25	0.015	46- 50	0.016	0.015
26-30	0.010	51-55	0.024	0.015
31-35	0.006	56-60	0.009	0.016
36-40	0.002	61-65	0.003	0.000
41-45	0.000	66-70	0.000	0.000

MEAN VALUE: 0.02

SOURCE: *AUTHOR'S CALCULATIONS AND CARTTER* [1976], *TABLE* 8-11.

IV. Initial age distributions

Because of their sampling scheme, as well as differential response rates among faculty ranks, the respondents to the Carnegie Council's 1975 survey of faculty are not representative of all U.S. faculty. Hence we needed to employ weights provided by the Carnegie Council staff to correct for these reponse biases in order that the age distribution among doctorate faculty in the sample be reasonably close to that in our population of interest. As this was a 5% sample, the results are accurate except for the very old cohorts, where the cell sizes are small.

Table A13 below provides a comparison of our age distributions of tenured and non-tenured faculty with that estimated by Bayer [1973] from the 1973 A.C.E. survey. The median ages of doctorate faculty are slightly less than for the faculty as a whole, reflecting the relatively large influx of new doctorate faculty during the sixties. The relative youth of the doctorate faculty in 1975 compared to all faculty also probably accounts for the slightly lower tenure ratio.

Table A13

AGE DISTRIBUTIONS

	1973 *FULL-TIME FACULTY*	1975 *FACULTY WITH PH. D.*
TENURED		
26-30	0.022	0.008
31-35	0.097	0.090
36-40	0.161	0.182
41-45	0.187	0.214
46-50	0.174	0.181
51-55	0.151	0.137
56-60	0.108	0.103
61-65	0.074	0.067
66-70	0.026	0.017
MEDIAN AGE	45.9	45.1
UNTENURED		
26-30	0.184	0.166
31-35	0.360	0.343
36-40	0.193	0.200
41-45	0.109	0.171
46-50	0.064	0.053
51-55	0.041	0.035
56-60	0.027	0.014
61-65	0.016	0.013
66-70	0.007	0.006
MEDIAN AGE	34.4	34.9
TENURE RATIO	.692	.687

SOURCE: BAYER [1973] AND CALCULATIONS FROM THE 1975

V. Ages at entry

When someone begins his or her academic career is difficult to determine. Many people obtain doctorates after having worked in academia for a number of years. Cartter estimated that between 1954 and 1964 306,000 new teachers entered academic employment with doctorates, while 214,000 continuing teachers received doctorates; this is a ratio of 1.4:1. This suggests that over 1/3 of the faculty in the Carnegie sample considered themselves to be continuing in academia at the time they received their doctorates. To the extent that this experience influences future rates of promotion or mobility, "year of entry" should be defined so as to include these pre-doctorate years.

Unfortunately, the 1975 survey provides very little information on the respondents' pre-doctorate academic career. We have had no real recourse, then, but to use the year of receipt of the doctorate as the "age of entry" into the academic labor market. Though this leads to an under-estimate of experience, it is tempered somewhat by the presence of a sizable number of respondents with post-doctorate fellowships (Radner and Kuh [1977]) whose "experience" we under-estimate.

Table A14 shows the distribution of ages at entry for each academic age (as of 1975). Although the conditional age distributions varied somewhat for the first 23 academic ages, we decided--for computational reasons--to assume that the distributions were constant over this range; hence for $1 \leq i \leq 23$, $\alpha(i,j) \equiv P$ {entered academia at age j | one has been in academia for less than 23 years} ,
which is the mean conditional distribution. We have then "smoothed" the matrix by replacing each column with the best fit by a fourth-degree

polynomial. Most of the changes were by less than 5%. For our projection period we have further assumed that the age distribution of new hires is constant, employing $\alpha(1,j,0)$ --the mean entry age of those who entered academia over the last 23 years. Although this assumption of constancy is not so unreasonable in our present situation where most new entrants are from graduate school, it would be untenable in a model that accounted for inter-sectoral flows. In that situation, most new entrants into one sector are people coming from other sectors of academia--not from outside academia--and the age distribution of these "movers" could vary considerably over time.

A more serious problem with our estimates is their instability when projected into the future. Our baseline retirement and death rates imply that the distributions of ages at entry (the rows of the matrix) for the older faculty quickly shift to the right after 1975. This suggests one or more of the following: (1) our mean age of retirement is too high, (2) our matrix is incorrect, or (3)retirement rates <u>are</u> a function of experience as well as age (whence our projections of $\alpha(i,j,t)$ are wrong).

Table A14

PROBABILITIES OF AGE AT ENTRY BY AGE IN ACADEMIA

ACADEMIC AGE	AGES AT ENTRY										
	26	27	28	29	30	31	32	33	34	35	≥36
1-23	0.089	0.119	0.107	0.104	0.092	0.082	0.068	0.054	0.049	0.037	0.199
24	0.048	0.160	0.115	0.117	0.076	0.097	0.093	0.058	0.048	0.038	0.150
25	0.101	0.055	0.114	0.125	0.162	0.082	0.087	0.047	0.050	0.048	0.130
26	0.090	0.031	0.100	0.104	0.168	0.083	0.075	0.043	0.047	0.048	0.210
27	0.073	0.058	0.107	0.097	0.170	0.113	0.080	0.054	0.053	0.054	0.140
28	0.048	0.101	0.109	0.084	0.143	0.142	0.080	0.064	0.055	0.054	0.120
29	0.031	0.124	0.100	0.068	0.097	0.148	0.070	0.063	0.047	0.044	0.210
30	0.037	0.154	0.110	0.070	0.076	0.164	0.072	0.070	0.046	0.041	0.160
31	0.061	0.167	0.121	0.080	0.061	0.171	0.071	0.071	0.042	0.034	0.120
32	0.113	0.179	0.146	0.103	0.062	0.180	0.075	0.073	0.040	0.029	0.000
33	0.186	0.159	0.155	0.119	0.068	0.155	0.067	0.061	0.031	0.019	0.000
34	0.222	0.139	0.165	0.134	0.083	0.123	0.059	0.046	0.021	0.009	0.000
35	0.269	0.129	0.173	0.144	0.103	0.088	0.050	0.030	0.013	0.002	0.000
36	0.302	0.138	0.178	0.146	0.122	0.054	0.040	0.015	0.006	0.000	0.000
37	0.317	0.173	0.180	0.137	0.135	0.025	0.031	0.003	0.000	0.000	0.000
38	0.311	0.234	0.176	0.116	0.136	0.005	0.023	0.000	0.000	0.000	0.000
39	0.300	0.317	0.168	0.085	0.125	0.005	0.000	0.000	0.000	0.000	0.000
40	0.358	0.369	0.139	0.044	0.091	0.000	0.000	0.000	0.000	0.000	0.000
41	0.340	0.511	0.138	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000
42	0.412	0.492	0.096	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
43	0.621	0.379	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

SOURCE: CALCULATIONS FROM THE 1975 CARNEGIE SURVEY OF U.S. FACULTY